"EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEAS (*Pisum sativum* L.)

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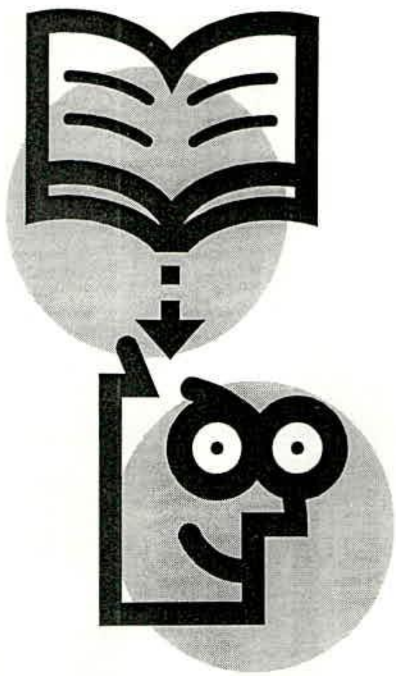

ABSTRACT

EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEAS (*Pisum sativum* L.)

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ABSTRACT

A field investigation was carried out during *Rabi* season of 2001-2002 on loamy sand soil of College Agronomy Farm, under AICRP on Weed Control, B.A. College of Agriculture, Gujarat Agricultural University, Anand to study the "EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEAS (*Pisum sativum* L.)". Eight weed management treatments comprising three pre-emergence herbicides each at two levels *viz.*, fluchloralin (0.45 and 0.90 kg/ha), pendimethalin (0.50 and 0.75 kg/ha) and alachlor (0.60 and 1.2 kg/ha). Hand weeding twice at 15 and 30 DAS and weedy check combined with and without *Rhizobium* inoculation under factorial randomized complete block design with four replications. Seed treatment with *Rhizobium* inoculation was given in the morning on the day of sowing. Herbicides application were made the next day of sowing with the help of knapsack sprayer fitted with a flatfan nozzle using 500 litre water/ha spray solution. The net plot size was 12.0 m^2. The pea crop (cv. Arkel) was sown on 27th November, 2001 with row spacing of 30 x 10 cm using seed rate 120 kg/ha. The crop received a uniform dose of 20 kg nitrogen, 75 kg phosphorus and 35 kg potash as urea, single super phosphate and murate of potash. The crop was harvested on 18th February, 2002.

The study indicated that among different weed management treatments, hand weeding twice at 15 and 30 DAS followed by pendimethalin 0.5 and 0.75 kg/ha were most effective in controlling weeds. These treatments reduced the dry weight of weeds (136.87, 522.29 and 585.10 kg/ha, respectively) by 88.00 to 97.2% as compared to unweeded control (4881.56 kg/ha). The *Rhizobium* inoculation treatments were not significantly different.

Of the different weed control treatments, the higher pod yield was obtained under treatment hand weeding twice at 15 and 30 DAS (8547 kg/ha), followed by pendimethalin 0.75 and 0.5 kg/ha and fluchloralin 0.9 kg/ha having 7724, 7314 and 7233 kg/ha, respectively. The yield differences among these treatments were not significant. Plant growth as well as yield attributing characters were higher under these treatments.

The *Rhizobium* inoculation treatments were not significant but they are superior than the lowest pod yield (3175.00 kg/ha) recorded under weedy check with weed index (62.85%).

Weed control practices restricted the nutrient removal by weeds substantially compared with the unweeded check. Weeds removed 262.63, 60.04 and 304.61 kg N, P_2O_5 and K_2O ha, respectively. The protein content (%) of pea seeds were also significantly influenced by weed management practices. The highest protein (9.18 %) was recorded during third picking in treatment W_3 (Pendimethalin 0.5 kg/ha). Correlation studies indicated that all weed parameters were negatively correlated with pod yield and yield attributes.

The highest net returns (Rs. 53,856/ha) was obtained by the hand weeding twice at 15 and 30 DAS + *Rhizobium* inoculation followed by hand weeding twice without *Rhizobium* inoculation, (indicates that seed treatment with *Rhizobium* inoculation was not much more beneficial) pendimethalin 0.5 kg/ha + *Rhizobium* inoculation which gave net profit of Rs. 50,328 and 50,099/ha, respectively. The benefit : cost ratio were also higher in these treatments (2.49 – 2.59).

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEAS (*Pisum sativum* L.)" submitted by **Shri Amitkumar Jayendrasinh Jhala** in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture) in Agronomy** of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision. The thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Anand
Date : 16 -10-2002

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(A.J. Jhala)

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Date : 16-10-2002

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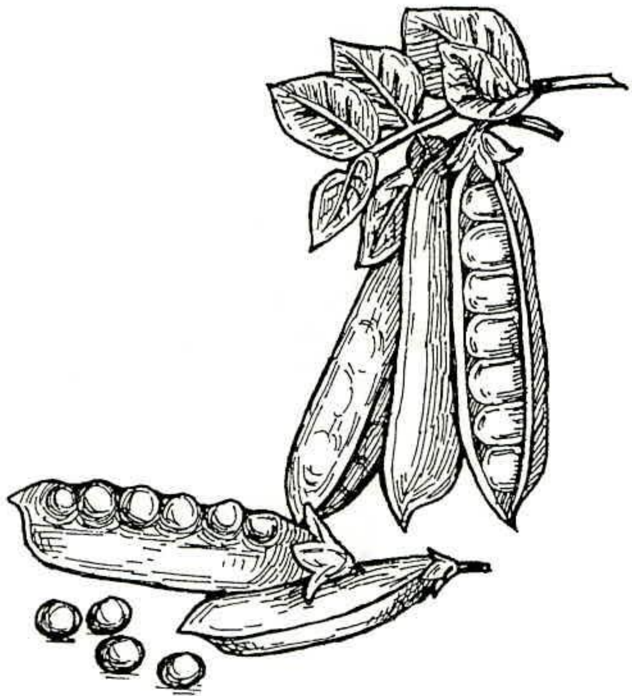
LIST OF ABBREVIATION

Anon.	Anonymous
@	At the rate of
°C	Degree Celsius
CBR	Cost benefit ratio
CD	Critical difference
cm	Centimeter
cv.	Cultivar
C.V.	Coefficient of variation
DAS	Days after sowing
et al.	et allii : and others
etc.	Etcetera
Fig.	Figure
g	Gramme
ha	Hectares
HI	Harvest index
hr.	Hour
ICBR	Incremental cost benefit ratio

i.e.	That is
kg	Kilogramme
m	Meter
max.	Maximum
min.	Minimum
mm	Millimeter
N	Nitrogen
No.	Number
NS	Non significant
%	Per cent
Rs.	Rupees
S.Em.	Standard error of mean
t	Tonne
var.	Variety
viz.,	Namely
WCE	Weed control efficiency
WI	Weed index
wt.	Weight



INTRODUCTION

I. INTRODUCTION

Pulses are among the ancient food crops with evidence of their cultivation for over last 8,000 years. Besides being a rich and the cheapest source of dietary protein and a valuable animal feed, they also play a key role in improving and sustaining soil productivity on account of biological nitrogen fixation. At present, the area under pulses is 24.07 million hectares with the production of 15.90 million tonnes with an average 661 kg/ha in India (Ali and Kumar, 2000).

Pea (*Pisum sativum* L.) is most important pulse crop of this country. It belongs to the family leguminoceae. Janick *et al.* (1969) described association of genus pisum with man atleast from stone age. It may be classified into two classes. (1) garden or table pea (*Pisum sativum* var. *hortense*). Green seeds of this type are used for vegetable purpose and for canning (2) field pea (*Pisum sativum* var. *arvense*). Mature seeds of this type are used as 'dal', this type is also used for green manuring. Green seeds are also canned for the use in the off season. It is mixed with dry fodder namely 'karabi' or 'bhusa' to make a palatable feed for the animals. It is very much nutritive and contains 7 to 9 per cent protein, 56.6 to 62.1 per cent carbohydrates, 1.5 to 1.8 per cent fat and appreciable proportion of calcium, iron, phosphorus and vitamins B_1, B_2 and niacin (Choudhury, 1967).

India is the 5th largest producer of peas in the world. Apart from India, other major producers of peas are USA, China, France, UK etc. The major peas growing states in India are Uttar Pradesh, Bihar, Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. The latest production of peas in India is 27.12 lakh tonnes (Anonymous, 2002) however, it is grown in the area of 0.70 million hectares with an average production of 857 kg/ha (Ali and Kumar, 2000).

The various agronomical practices like sowing time, *Rhizobium* inoculation, spacing, seed rate, fertilizer application, insect pest and disease control, weed management etc. plays an important role in maximization of peas production per unit area. Among all these factors weed management practices and *Rhizobium* inoculation play the key role in increasing the production of pea crop.

Being a leguminous crop, pea can fix unavailable atmospheric nitrogen into available form in symbiosis with *Rhizobium* and thus has low nitrogen requirement. About 25% of the crop nitrogen is in plant residues (Jenson, 1989). The *Rhizobium* inoculation is a cheap, easy and safe method of supplying nitrogen to legumes and the yield of peas can be considerably increase by using an effective inoculum properly. Efficient strains of Rhizobia can fix 80 to 150 kg of nitrogen per hectare in one planting season. Like other bacteria, Rhizobia multiply in laboratory culture and now it is possible to produce them on a commercial scale for inoculation purposes (Singh and Choubey, 1971).

The successful cultivation of pea is encountered with many problems particularly weed management which needs to be tackled on top priority because yield losses may be as high as 40-64% depending upon weed flora (Randhawa *et al.,* 1980). Not only yield but also the quality of pea is adversely affected by weeds (Gautam and Singh, 1971).

Importance of herbicide as a substitute or supplement to manual weeding in peas has been reported by Singh *et al.* (1974) and Bhan and Tripathi (1979). However, the efficacy of herbicides may vary due to variation in agro-climatic conditions of the region.

Keeping this in view, the present investigation was planned with following objectives.

(i) To find out the effective and economical practices of weed management in peas.

(ii) To study the efficacy of different herbicides for controlling weeds in peas.

(iii) To study the effect of *Rhizobium* inoculation on growth and yield of peas.

(iv) To study the interaction effect of weed management practices and *Rhizobium* inoculation.

(v) To assess the economic feasibility of using *Rhizobium* inoculation and weed management practices.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The literature pertaining to the present investigation is reviewed and presented in following topics.

2.1 EFFECT OF WEED MANAGEMENT PRACTICES

2.1.1 Alachlor

2.1.1.1 Effect of Alachlor on weed flora

2.1.1.2 Effect of Alachlor on growth, yield and yield attributes of pea

2.1.2 Fluchloralin

2.1.2.1 Effect of Fluchloralin on weed flora

2.1.2.2 Effect of Fluchloralin on growth, yield and yield attributes of pea

2.1.3 Pendimethalin

2.1.3.1 Effect of Pendimethalin on weed flora

2.1.3.2 Effect of Pendimethalin on growth, yield and yield attributes of pea

2.2 EFFECT OF *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEA

2.3 INTERACTION EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION

2.1 EFFECT OF WEED MANAGEMENT PRACTICES

2.1.1 Alachlor : For more detail see Table 3.6

2.1.1.1 Effect of Alachlor on weed flora

Harvey *et al.* (1972) conducted field experiment in 1970-71 to study effect of herbicides in pea cv. Alaska and Perfection Alachlor @ 2.2 kg/ha and 3.4 kg/ha and propachlor 5.6 kg/ha as pre-emergence gave satisfactory control of most of the broad leaved weeds.

In a trial in peas cv. Perfection grown on a clay soil, Marsico *et al.* (1972) applied alachlor @ 1.4-2.0 kg/ha as pre-emergence, 3 days after sowing controlled annual weeds and was selective to the crop.

Jordan and Harvey (1976) investigated of acetanilide herbicides in the field and glasshouse in 1975-76 in canning pea. Alachlor applied pre-emergence at 2 and 4 lb or applied early post emergence at 2 and 4 lb/acre provided excellent control of grasses.

Vishnoi *et al.* (1983) conducted experiment at Agriculture Research Unit, Hawalbagh, Almora during 1978-79 in peas. Alachlor @ 1 to 2 kg./ha reduced the number of weeds considerably followed by nitrofen @ 1.0 kg/ha.

Nandal and Arya (1995) studied the efficacy of three herbicides, namely alachlor (1.0, 1.5 and 2.0 kg/ha), thiobencarb (1.0, 1.5 and 2.0 kg/ha) and glyphosate (1.0, 1.5 and 2.0 kg/ha), were compared with weed free and weedy check treatments in peas cv. Arkel. All herbicides as well as hand weeding treatments significantly reduced the fresh and dry weight of weeds.

Georgieva (1998) carried out a multiple factor field experiment during 1992-94 at pazardzhik, Bulgaria. With the application of Lasso (alachlor) + Ceazin (4 : 2), weed density decreased by a factor of 20 to 40. Ploughing before the pea triticale mixture was twice as effective in lowering the weeds density than discing.

2.1.1.2 Effect of Alachlor on growth, yield and yield attributes of pea

In a trial in peas cv. Perfection grown on a clay soil Marsico *et al.* (1972) revealed that dense sowing (8 rows/ 5.5 x 1.8 m plot) without herbicide treatment gave crop yields and weed control superior to that obtained from treated (alachlor @ 1.4-2.0 kg/ha) plots containing 4 rows each.

Doerch *et al.* (1974) concluded that alachlor @ 3 lb/acre, pre-sowing followed by 2.5 lb/acre pre-emergence resulted in yields as good as or better than the standard EPTC or chloramben treatments on sandy loam soil in beans.

In tests in 1979-80 with pea cv. Ressen 3 grown for seed, Boyadzhiev and Kak (1981) gave soil applied treatment of Lasagreen (alachlor 48%) @ 4 lit/ha + Patoran (metobromuron 50%) @ 3 kg/ha gave seed yields significantly higher than that of the control and there was no phytotoxic effect or adverse effect on seed quality.

Vishnoi *et al.* (1983) conducted the experiment at Agri. Res. Unit, Hawalbagh, Almora in pea by using 3 herbicides. In comparison to control all the treatments proved to be superior and an increase in yield ranged from 18.54% (propanil @ 1 kg/ha) to 40.00% (alachlor @ 1 kg a.i./ha). Thus, among all three herbicides used, alachlor @ 1 to 2 kg a.i./ha proved to be best followed by propanil @ 2 kg a.i./ha.

Saimbhi *et al.* (1990) revealed that isoproturon @ 0.98 kg/ha, methabenzthiazuron @ 1.35 kg/ha and their combinations @ 0.62 kg/ha with alachlor @ 1.25 kg/ha gave good green pod yield. Alachlor @ 2.5 kg/ha gave poor yield but with supplementary weeding it gave pod yield at par with weeded control.

Nandal and Arya (1995) studied the efficacy of three herbicides, namely alachlor (1.0, 1.0 and 2.0 kg/ha), thiobencarb (1.0, 1.5 and 2.0 kg/ha) and glyphosate (1.0, 1.5 and 2.0 kg/ha) were compared with weed free weedy check treatments in peas cv. Arkel. None of the herbicides were injurious to the crop plants. All herbicides as well as hand weeding increased the seed yield of peas over weedy check. Maximum seed yield was recorded with alachlor at 1.0 kg/ha.

2.1.2 Fluchloralin : For more detail see Table 3.6.

2.1.2.1 Effect of Fluchloralin on weed flora

Singh *et al.* (1974) indicated that Basalin application at the rate of 3 lit/ha controlled many kinds of weeds in field pea.

In glasshouse trials, Harvey and Jacques (1977) evaluated eight substituted dinitroaniline herbicides over 3 years for weed control and crop tolerance in peas. All the herbicides at 0.84 or 1.68 kg/ha successfully controlled the weeds present.

At Ludhiana and Jullundur, Randhawa *et al.* (1981) applied fluchloralin as pre-sowing and other herbicides as pre-emergence in peas. Fluchloralin @ 0.5-1.0 + methabenzthiazuron @ 0.93 kg and fluchloralin @ 0.5-1.0 + metribuzin @ 0.5 l/ha were effectively control all the weeds.

Bhalla and Chourasia (1982) evaluated that fluchloralin @ 0.9 lit/ha was top ranking in controlling weeds in pea.

Bhalla and Sarangthem (1982) concluded that weed intensity was significantly reduced with prometryn and alachlor, but not with fluchloralin @ 0.45 lit/ha in pea.

Rathi *et al.* (1982) conducted trials with peas in 1978-80. Fluchloralin @ 1-1.5 kg/ha pre-sowing and pendimethalin at the higher rates gave almost the same control as 2 weedings and they were effective in providing season long control of *Chenopodium album* and *Fumaria parviflora*.

Bhalla and Chourasia (1985) studied the effects of 9 herbicides on weed control and growth of garden pea. Basalin (fluchloralin) @ 2 lit/ha gave most effective weed control. Igran (terbutryn) was superior to Basalin in weed control efficiency, but was toxic to the crop.

Rathi *et al*. (1986) concluded that pre-sowing incorporation of 1.5 kg fluchloralin gave effective weed control in peas similar to 2 hand weedings.

In 1985-86, Saimbhi *et al*. (1990) studied weed control in peas cv. Punjab 88 and concluded that fluchloralin @ 0.8 and 1.2 kg/ha gave good weed control.

At Rajasthan during 1990-91, Singh and Nepalia (1994) conducted field trials on clay loam soil, the effects were evaluated of fluchloralin @ 0.75-1.0 kg/ha, pendimethalin @ 0.75-1.0 kg/ha and hand weeding for control weeds in peas. Weed control efficacy at harvest ranged from 59.53 to 94.59%, with hand weeding resulting in the greatest weed control and pendimethalin @ 0.75 kg resulting in the least weed control.

2.1.2.2 Effect of fluchloralin on growth, yield and yield attributes of pea

In a trial, Singh *et al.* (1974) applied herbicides @ 2-4 lit/ha in 600 lit. water 2 days before sowing peas cv. Improved Little Marvel, Basalin [fluchloralin (36%)] incorporated lightly into the soil @ 3 lit/ha resulted in a 98% increase in the yield compared to control plots which were weeded once 1 month after sowing.

Under field conditions during 1974-75, Teasdale and Harvey (1976) stated that a number of dinitroaniline compounds increased the yield of peas as a result of root rot suppression, of which, fluchloralin @ 0.75 lb/acre and trifluralin @ 0.5 lb + oryzalin @ 0.5 lb gave the highest increases (66 and 70% respectively).

Harvey and Jacques (1977) evaluated eight substituted dinitroaniline herbicides over 3 years for weed control and crop tolerance in peas. The highest average pea yields resulted from the use of oryzalin, dinitrimine and fluchloralin.

In a field experiment, Bhalla and Chourasia (1982) concluded that weed control efficiency of all the 16 treatments differed significantly. Fluchloralin @ 0.9 lit/ha was top ranking in seed yield. It provided a weed free environment without any adverse effect on crop growth, through its efficiency was slightly lesser than terbutryne @ 0.9-1.5 kg/ha.

Randhawa *et al.* (1981) given fluchloralin as pre-sowing and other herbicides as pre-emergence in peas. Methabenthiazuron at 0.93 kg + fluchloralin at 0.5 lit. and fluchloralin at 0.5 lit. + metribuzin at 0.5 lit/ha were effective in increasing seed yields.

Bhalla and Sarangthem (1982) concluded that the presence of 211 weeds/m^2 during the growth period of peas decreased the seed yield by 23.98%.

Prakash and Pahwa (1982) studied the effect of herbicides on growth of pea cv. Banville in pot trials. Herbicides in general reduced root length but not shoot length. At later stage of growth, shoot dry wt. was increased by fluchloralin at all rates (0.5, 0.75 and 1.0 kg). Treated plants had more leaves than the control. Fluchloralin at 1 kg/ha increased the number of nodules/plant.

In trials with peas in 1978-80 Rathi *et al.* (1982) revealed that the yield reduction due to weeds was 24.6-35.2%. Fluchloralin and pendimethalin at higher rates gave consistently higher yields than other treatments.

Bhalla and Chourasia (1985) concluded that Basalin (fluchloralin) @ 2 lit/ha gave the highest yields and had no adverse effect on growth of pea (*Pisum sativum* L.).

Rathi *et al.* (1986) evaluated that in pea, pre-sowing incorporation of 1.5 kg fluchloralin gave similar yields to 2 hand weedings. The uncontrolled weeds decreased yields by 24.3 – 35.2% in 3 years.

At Rajasthan during 1990-91 Singh and Nepalia (1994) conducted field trails on clay loam soil in pea. All weed control treatments (fluchloralin @ 0.75-1.0 kg/ha, pendimethalin @ 0.75-1.0 and hand weeding) increased grain and stover yields from untreated control values of 0.68 and 1.05 t/ha resp. to 1.13-1.87 and 1.26-1.83 t, resp., with hand weeding resulting in the greatest yields.

Mishra and Bhan (1997) conducted field experiment in 1993-95 at Jabalpur, Madhya Pradesh, 2 pea cultivars were treated with 1.0 kg/ha fluchloralin, hand weeded at 30 DAS. The major weeds reducing seed yield by 24-29%. Treatments with fluchloralin produced similar seed yields as hand weeding 30 DAS. The seed yield was significantly negatively correlated with weed dry matter/m^2.

2.1.3 Pendimethalin : For more detail see Table 3.6.

2.1.3.1 Effect of pendimethalin on weeds

Rathi *et al.* (1986) studied the effect of five herbicides in peas and concluded that pendimethalin at higher doses being almost at par with two weeding at 3 and 6 weeks after sowing gave season long weed control as compared to other treatments.

Gogoi *et al.* (1991) conducted the field trials on sandy loam soil at Jorhat during 1985-86 for weed control in peas cv. T-163 and stated that pendimethalin @ 1.5 kg/ha resulted in the greatest weed control efficiency values 62.7 – 65% as compared to benthiocarb @ 1.2-1.5 kg/ha, metolachlor @ 1.5-2.0 kg/ha, bentazon @ 0.5-1.0 kg/ha.

Tagic (1995) evaluated the efficacy of different herbicides on weeds of peas in 1991 and 1992 seasons. The best average efficacy, as assessed by the number of weed plants, was attained by the mixture of pendimethalin + prometryn (87.09 % control).

In field experiments in 1995 and 1996, Auskalnis (1997) concluded that pendimethalin applied at 3 lit/ha as pre-emergence was the most effective for weed control. After application, the number of weeds decreased by 36-52%.

In 1995 and 1996, at the Kaltinenai Research Station of the Lithuanian Institute of Agriculture on hilly moderately eroded clay loam soil, Kinderiene (1997) stated that stomp [Pendimethalin] (5 lit/ha) reduced the number and weight of annual weeds.

Mishra and Bhan (1997) conducted experiment during 1993-94 and 1994-95, two varieties of pea were subjected to the treatment of pendimethalin @ 1 kg/ha, hand weeding (HW) at 30 DAS weed free and weedy check to assess the relative response in terms of weed control. Pendimethalin @ 1 kg/ha successfully controlled all the weeds like chicory (*Cichorium intybus* L.), lambs quarter (*Chenopodium album* L.), common vetch (*Visia sativa* L.) and field bind weed (*Convolvulus arvensis* L.).

2.1.3.2 Effect of pendimethalin on growth, yield and yield attributes

Prakash and Pahwa (1982) studied the effect of some new herbicides on growth of pea cv. Bonville were studied in pot trials. At later stages of growth, shoot dry weight was increased by pendimethalin at 1.5 and 2 kg/ha. Treated plants had more leaves than the control. Pendimethalin at 1 and 1.5 kg/ha increased the number of nodules/plant.

Rathi *et al.* (1986) evaluated the effect of herbicides in field pea. The yield reduction in peas was 35.2, 24.3 and 28.0 per cent during 1978, 1979 and 1980 respectively. Pendimethalin and fluchloralin at higher doses being almost at par with two weeding at 3 and 6 weeks after sowing gave consistently higher yields and season long weed control as compared to other treatments.

At Jorhat during 1985-86, Gogoi *et al.* (1991) conducted field trials on sandy loam soil to study the chemical control of weeds in field peas. Manual weed control resulted in the greatest weed control efficiency (66.2%) and resulted in the greatest grain yields (1263 kg/ha) as compared to untreated control value (416 kg). Of the herbicide treatments, oxadiazon at 0.5-1.0 kg and pendimethalin at 1.5 kg resulted in the greatest grain yields (1170-1177 and 1196 kg respectively).

At Hyderabad in 1992-93, Tripathi *et al.* (1993) conducted field trials on clay loam soil to determine effect of herbicide in peas cv. Bonnevelle. Pendimethalin at 0.5 kg + 1 hand weeding stimulated the growth of *Trichoderma harzianum* (a potential biocontrol agent). The best weed control and greatest pea yields (6606 kg/ha) were observed with pendimethalin at 0.5 kg + 1 hand weeding 20 DAS.

Auskalnis (1997) studied the effect of Stomp, Harness and Topogard on weed incidence and grain yield in peas during 1995-96. Application of Harness and Topogard resulted in the reduction of pea stand weediness by 33-66%, but these herbicides did not increase crop yield. Stomp applied at 3 lits/ha increased the grain yield of peas by 0.35 t/ha (8.5%).

In 1995 and 1996, at the Kaltinenai Research Station of the Lithuanian Institute of Agriculture on hilly moderately eroded clay loam soil, Kinderiene (1997) studied the weed control in peas cv. Odin. The yield of peas increased after application of Stomp at 4 lits/ha (3.2%) and 5 lits/ha (6.2%), while Harness at 2.0 lits/ha significantly reduced pea yield.

Mishra and Bhan (1997) conducted an experiment during 1993-94 and 1994-95, two varieties of pea were subjected to the treatment of herbicides. The weeds causing 24-29% reduction in grain yield. Pea 'JP-885' showed significant reduction in weed population than 'JM-1' and increase in grain yield. Pendimethalin 1 kg/ha resulted in similar grain yield with that of hand weeding at 30 days. The yield of pea was significantly negatively correlated with weed dry matter/m^2. With the increase of 1 g. dry matter/m^2, the rate of reduction in grain yield was 3.185 $\pm$ 1.253 kg/ha and 49.165 $\pm$ 7.754 kg/ha during 1993-94 and 1994-95 respectively.

Ved *et al.* (2000) evaluated that season long crop weed competition reduced the green pod yield by 44.6 – 55.6% as compared to repeated weeding. All the weed control treatments resulted in significantly higher green pod yield over weedy check. Pendimethalin 0.5 kg/ha followed by HW 45 DAS yielded as good as repeated weeding and gave maximum additional net returns over weedy check (Rs. 40708/ha). Highest plant height, pods/plant, grains/pod, pod length, pod weight/plant and shelling percentage were recorded under repeated weeding closely followed by pendimethalin 0.5 kg/ha + HW 45 DAS. Herbicides alone increased green pod yields by 55.9 – 75.9% over weedy check.

2.2 EFFECT OF *RHIZOBIUM* INOCULATION ON GROWTH AND YIELD OF PEA

The pea being a leguminous crop can fix atmospheric nitrogen in the symbiosis with *Rhizobium*. Rhizobia enter the legume root through minute hairs present on young roots. Their entry into the plant is followed soon by swelling on the side of the root, which are known as nodules. These nodules are the home of millions of rhizobia during their association within the plant.

Inoculation of legumes provide an insurance against crop failure caused by the lack of sufficient nitrogen. The young plants may suffer due to nitrogen starvation during the period when they are forced to draw their needed nitrogen directly from the soil. If the proper rhizobia are applied to the seed at the time of planting, the period of nitrogen hunger is never a critical one.

The major advantage of *Rhizobium* inoculation is that air nitrogen is made available in such a cheap, easy and efficient way that the plants find it unnecessary to draw heavily upon the soil supply. Large increases in crop yields are obtained on soils low in available nitrogen.

Hulamani *et al.* (1972) conducted trial during the year of 1968-69, seeds of pea cv. New Line Perfection was inoculated with (a) *Rhizobium* culture alone or (b) in combination with 1% sodium molybdate or (c) were treated with 1% sodium molybdate or (d) were left untreated. Nodulation was highest with (a) and yield of fresh pods were highest with (b).

Gupta *et al.* (1973) described the technique consisted of spraying the flowers with concentrated *Rhizobium* inoculum 3 times at 2 day intervals. The resulting seeds of *Phaseolus radiatus, P. aurens, Vigna* *sinensis, Cicer arietinum* and *Pisum sativum* produced plants which nodulated in sterilized soil.

Fiuczek (1976) concluded that *Rhizobium* inoculation was a more efficient source of nitrogen for field peas than mineral N.

Shukla *et al.* (1978) stated that seed yields and CP contents of peas grown from inoculated and uninoculated seeds were increased by the application of 40 kg P_2O_5 or 0.5 kg ammonium molybdate/ha. Yields were higher with seed inoculation than without it.

In pea, association of *Rhizobium* with a strain of *A. chroococcum* isolated from the rhizosphere of pea gave higher yield than *Rhizobium* alone (Jauhri *et al.*, 1979).

Ram and Sanoria (1979) evaluated the effects of seed inoculation with 3 *Rhizobium* strains and/ or 2 Azotobacter strains on nodulation and seed yields of peas grown on 2 alkali soils differing in chemical and microbiological characters were determined. The gain in soil N due to seed inoculation was positively correlated with nodule number, but not with dry wt. of nodules. Average seed yield was the highest with inoculation with *Rhizobium* strain F10 + Azotobacter strains Bs.

Broughton *et al.* (1980) studied the nodulation of *Pisum sativum* cv. Afghanistan by *Rhizobium leguminosarum* strain Tom can be blocked by the non-nodulated *R. leguminosarum* strain PF2 colonized the root surfaces earlier and in greater numbers than did Tom.

Prasad and Maurya (1989) carried out an experiment during the rabi season during 1983-84 to study the effects of application of P_2O_5 at 0, 40, 80 or 120 kg/ha with or without *Rhizobium* inoculation of seeds of garden pea. P_2O_5 application, *Rhizobium* inoculation alone or in combination resulted in significant increases in growth, nodulation and yield, compared with the control. The highest green pod yield was obtained with a combination of 120 kg P_2O_5/ha and *Rhizobium* inoculation.

Champawat (1990) revealed that dual inoculation of pea plants with *Gigaspora calospora* and *Rhizobium* resulted in greater increases in shoot and root DW, P and N uptake, nodulation and mycorrhizal infection than single inoculations.

In pot tested with 5 *Rhizobium leguminosarum* strains, 3 newly bred varieties and the control variety Bohatyr, significant differences between treatments were found for all the traits tested except seed yield. Inoculation with selected strains in most cases increased seed yield in comparison with use of unselected native, rhizobia (Simon, 1990).

In green house experiments, peas cv. KPSD-5 and Pusa-10 and lentils cv. PL-639 and Pl-406 were given saline irrigation water (4 ds/m), 0, 30, 60 or 90 kg P_2O_5/ha and inoculated with *Rhizobium* *leguminosurum* or not inoculated. Inoculation increased DM, yield, P uptake, P derived from fertilizer and P utilization in both crops, Dravid (1991).

Garg *et al.* (1991) evaluated that DW and N content were higher in pea cv. HP-41 plants inoculated with the Hup^+ *R. leguminosarum* strain VP1 than with its plasmid-cured Hup^- derivative Vm 1. A lower proportion of 14 CO_2 assimilated by the plants was translocated to the roots and nodules after inoculation with the Hup^+ strain than with the Hup^- strain.

Biedermannova and Vondrys (1992) conducted a field trials in 1988-90 at Ctyri Dvory, peas cv. Bohatyr were inoculated with the commercial preparation Rhizobin, *Rhizobium* reducing (nitrogenase) activity was, on average highest with D-28, increased by D-253 and unaffected by Rhizobin reduced above ground biomass insignificantly compared with uninoculated plants.

Simon *et al.* (1992) collected 32 dried soil samples to inoculate pea plants and compared with low and high efficiency strains of *R. leguminosarum* cv. Viciae in hydroponic culture using perlite. Total nitrogenase activity was lower in soil inocula originating from higher altitudes. The low efficiency of native *Rhizobium*, even from good soils under favourable conditions, indicated that inoculation with commercial preparations may e worthwhile.

Freitas *et al.* (1993) studied the effects of inoculating field peas (*Pisum sativum*) with *Rhizobium leguminosarum* alone or in combination with *Pseudomonas syringae* R25 and/or *P. putida* R105, were assessed under gnotobiotic conditions in growth pouches and in potted soil in a growth chamber. Nodulation of pea seeds with *R. leguminosarum* and either of the pseudomonas significantly ($P < 0.01$) increased shoot, root and total plant weight in growth pouches, but had no effect in soil.

Krugova *et al.* (1994) conducted the experiments with 4 varieties differing markedly in morphological traits and inoculated with the commercial *Rhizobium* strains 250a and 2 new Ukrainian strains (P2 and M2). Solara had the highest protein content of the seed with strain M2, while all strains increased the protein content of Raport (11-25%) increase and none increased that of Khar 'Kovskii 28', which had the lowest protein content of the seed.

In field trials in various parts of the Ukraine, soyabeans, peas and *Medicago sativa* were grown from the seeds inoculated with peat preparations of *BradyRhizobium japonicum, Rhizobium leguminosarum* and *R. meliloti*, respectively or from uninoculated seeds. Inoculation increased seed yields of soyabeans and peas by 0.19-0.37 and 0.12-0.17 t/ha and protein yield by 14-32 and 18-25% respectively, and increased *M. sativa*

FW yield by 5.7-6.7 t/ha and protein yield by 31-35% (Krugova *et al.*, 1994).

Fesenko *et al.* (1995) demonstrated from an analysis of 481 *Rhizobium leguminosarum* cv. Viceae strains with 7 pea cultivars in pot and field experiments that the proportion of the isolates significantly increasing N accumulation in pea plants (10.2%) is higher than that of strains increasing the shoot dry mass (4.6%) in the pot experiments. The mean values of the increase for N accumulation (33.8%) upon inoculation are also higher than for shoot mass (27.0%) in these experiments.

Krishan *et al.* (1995) showed that multi strain inoculants were as good as the most effective single strain inoculants. The percentage of nodules occupied, nodule DW, plant DW and grain yield per plant using the multi strain inoculant were highly promising. In pea, *Rhizobium leguminosarum* strains RC1 01 and PO 12, were more effective than single strains in acidic soils of both the hills and valleys.

Wange and Patil (1995) conducted a field trial in rabi [Winter] 1989/90 at Pune, Maharashtra, pea cv. Boneviella, Wai local, Selection-82 and Selection-93 seeds were inoculated with 3 strains of *Rhizobium leguminosarum*. Number of nodules/plant were highest in Bonevilla, whereas nodule DW/plant was highest in Selection-82. Pod yield was highest in cv. Wai local (4.28 t/ha) and lowest in cv. Bonevilla (2.39 t). Seed inoculation increased pod yield by 25.8-66.7%.

Igbasan *et al.* (1996) studied the effects of location, nitrogen application and *Rhizobium* inoculation on variations in seed protein content and amino acid (AA) composition of field peas were examined. The concentrations of N fertilization examined were : 56, 75, 100, 125, 150 200, 250 and 300 kg/ha. At each concentration of N application, seeds planted were either *Rhizobium* inoculated or not inoculated. Seed protein content increased with increasing concentration of N application. No significant effect of seed inoculation was observed.

Feng *et al.* (1997) tested a bacterial, isolate from nodules of peas on different pea cultivars in various soil types. Effective nodules were produced by the nirtragin prepared from the isolated nodule bacteria. The bacterial strain isolated was a strain of *Rhizobium* sp. After inoculation with the bacterial strain, plants grew more vigorously with more branches, more effective flowers, and increased number of pods. The application of nitragin to peas in the field increased pod yield by 14%.

Kanaujia *et al.* (1998) conducted a field experiment during 1994-95 in Himachal Pradesh, peas were seed inoculated with *Rhizobium* or not inoculated, and given 0-90 kg/ha each of P_2O_5 and K_2O. Seed inoculation plus the application of 60 kg each of P_2O_5 and K_2O gave the highest pod yield of 13.17 t/ha.

2.3 INTERACTION EFFECT OF WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION ON PEAS (*PISUM SATIVUM* L.)

Schulke (1971) studied the effect of herbicidal and sub-herbicidal concentrations of prometryne on growth and development of nodulated and non-nodulated peas cv. Senator grown in nutrient solution were investigated. In non-nodulated peas under optimum growing conditions, 10-4 M prometryne adversely affected growth and nitrogen yield, but increased plant nitrogen percentage. Number of ripe seeds/pod was increased by low concentrations of prometryne, but not the number of ovules. Growth stimulation was absent in nodulated plants, in which concentrations or prometryne giving weak inhibition of growth decreased the yield of N in nodules (i.e. inhibited N fixation).

Torstensson (1975) evaluated the effects of bentazone and dinoseb on pure cultures of *Azotobacter chroococcum, Rhizobium leguminosarum, R. meltiloti, R. phaseoli, R. trifolii* and on the functional groups of protyolytic organisms, ammonifiers, nitrigiers, denitrifiers, sulphate reducers and cellulolytic organisms. The effects of bentazone, dinoseb and MCPA on the *Rhizobium leguminosarum* symbiosis for lucern, white clover, field bean and pea were investigated. Bentazone and dinoseb has approximately same effect on symbiosis expressed in terms of nitrogen fixation and d.m. production by the plants. The effects of MCPA appeared at rates one tenth of those at which the other 2 herbicides were effective.

Islam and Afandi (1982) studied the response of winter sown rainfed chickpea to herbicide application and *Rhizobium* inoculation during 1978-79. Only Tribynyl (methabenzthiazuron) at 4 kg/ha controlled weeds without affecting nodulation or chickpea growth. Metribuzin at 1 kg/ha and alachlor at 3 l/ha destroyed the crop. In further trials the effects of *Rhizobium* inoculation in conjunction with Tribunil at 4 kg/ha was studied in various chickpea cv. Interaction between *Rhizobium* strains and weed control treatments was not significant.

Magu and Bhowmik (1984) studied the effect of different rates (recommended rate, 2 x or 5 x) of the herbicide MCPB and the insecticide Disyston (disulfoton) on legume *Rhizobium* symbiosis and rhizosphere microflora was investigated using pea as test crop. The recommended rate of these pesticides inhibited nodulation during the initial stages growth (4^{th} week), but at later stages no differences in nodulation between treated and untreated plants were observed. MCPB was inhibitory to the bacterial population, while Disyston showed a stimulatory effect.

Rensburg *et al.* (1984) tested thirteen herbicides for toxicity against strains of *Rhizobium* used in South Africa legume inoculants for lucerne, clover, soybeans, groundnuts and lupins, respectively. Each of alachlor, bromoxynil, proprop, metolachlor, naptalam + dinoseb and tribluralin inhibited atleast two of the strains after a contact period of Ca 10 S. No strain survived 42 h in contact with any of these herbicides. Atrazine and terbutryn were relatively non-toxic. The slow growing strains of *Rhizobium japonicum*, *R. lupini* were less affected by at least two of the herbicides tested than strains of the fast growth *R. meliloti* and *R. trifolii*.

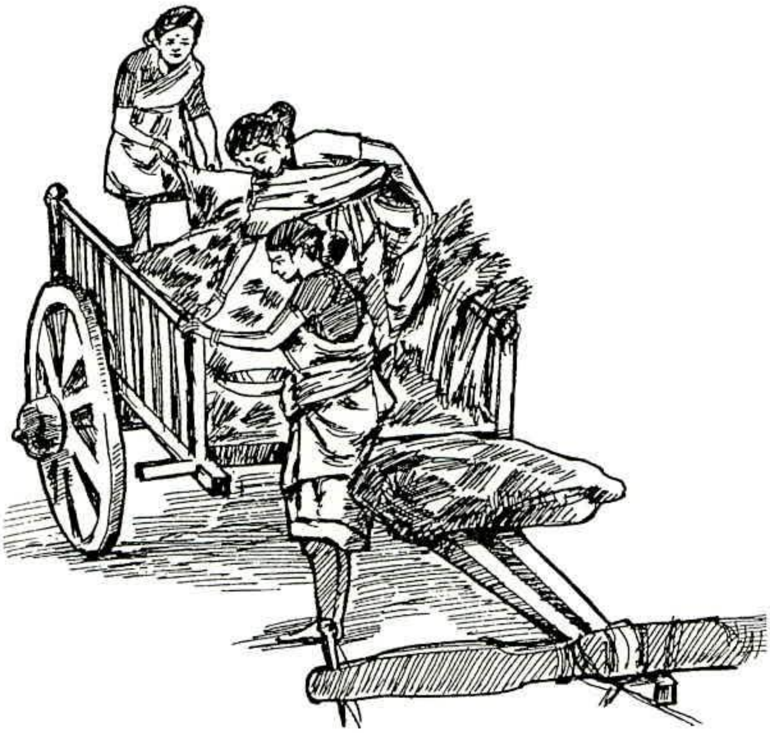
In a green house experiment, pea cultivar *Vladovskii lubileinyi* was grown in soil containing 6 mg prometryn/kg. Prometryn reduced green plant weight, nitrogenase activity, nodule size and nodule leghaemoglobin contents. The structure of the nodules showed destruction of the cytoplasm and nucleus of plant cells and lysis of the bacterials (Paromenskaya and Labskii, 1985).

Pahwa and Prakash (1992) conducted an experiment of chickpeas cv. Gaurav, seed inoculated with *Rhizobium* and grown in pots, were treated with 0.25, 0.5 or 0.75 kg metribuzin or 0.75, 1.0 or 1.25 kg pendimethalin/ha applied to the soil surface 2-D after sowing, while 0.5, 1.0 or 1.5 kg fluchloralin/ha was incorporated into the soil before sowing. At 75 DAS, nodule number was decreased by all treatments except 0.5 kg fluchloralin. Nodule DW was increased by the lowest fluchloralin concentration, decreased by higher rates of all herbicides, and most adversely affected by higher rates of pendimethalin.

Madhavi *et al.* (1994) studied the effects of 15 pesticides on nodulation, nitrogenase activity and sym plasmids in *Rhizobium* sp. IC-3342 nodulating *Cajanas cajas*, *Rhizobium leguminosarum* nodulating lentil and *R. meliloti* nodulating *Medicago sativa* were examined. Thirteen of the pesticides showed 55-100% loss of nodulation and nitrogenase activity of *Rhizobium* sp. IC-3342. Of the 6 insecticides, only sumicidin showed a loss of nodulation and nitrogenase activity with *R. leguminosarum*, whilst fungicides showed losses of 20-40% and herbicides 35-75% in both cases.

Promenskaya *et al.* (1998) studied the ability of collection strains of root nodule bacteria *Rhizobium leguminosarum, R. lupini, R. meliloti, R. trifolii, R. galegae and R. phaseoli* to degrade prometryn and 2,4-D was studied. Most strains could degrade prometryn on artificial nutrient medium. A few strains had high degrading activity towards prometryn, but none degraded 2,4-D. Inoculating pea and lupin seeds with herbicide degrading strains increased the efficacy of herbicide detoxification in soil and the herbicide resistance of legume-rhizobial symbioses.

Sawicka and Selwet (1998) determined the effect of two herbicide active ingredients (imazethapyr and linuron) on symbiotic nitrogen fixation activity and micro-organisms under legume crops, in a field experiment in Poland. The studies indicated that both imazethapyr and linuron can cause a decrease of root nodule bacteria nitrogenase activity. They can also stimulate development of bacteria and inhibit growth of fungi.



MATERIALS AND METHODS

III. MATERIALS AND METHODS

The details of materials used and the techniques adopted during the course of investigation are elaborated in this chapter.

3.1 EXPERIMENTAL SITE

In order to achieve the objective set forth for present investigation, a field experiment was conducted during *Rabi* season of the year 2001-2002 at the AICRP – Weed Control, College Agronomy Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand. Geographically Anand is situated at 20°-35' North latitude, 72°-35' East longitude with an elevation of 45.1 m above the mean sea level.

3.2 CLIMATE AND WEATHER CONDITIONS

The climate of Anand region is semi-arid and tropical with hot summer and cool winter. In this region, generally monsoon commences in the month of June and retreats by the end of September. Most of the rainfall received from South-West monsoon currents. July and August are the months of heavy showers. The average annual rainfall of this region is about 868.00 mm. Minimum temperature during rainy season ranges from 20 to 35 °C. Winter set in the month of November and continues till the middle of February. December and January are the coldest months of the year. April and May are the hottest months with the temperature rising as high as 43 °C and occasionally touching 44 °C. Monthly average wind velocity varies from 1.9 to 7.5 km/hr. with an average annual wind speed of 4.3 km/hr. The relative humidity is low during March, April and May.

Table 3.1 : Mean weekly weather parameters recorded at the Meteorological observatory, Anand during the crop season in year 2001-02

Month and year	Std. week	Temperature °C			Mean RH (%)	Sun-shine (hrs.)	Evapo-ration (mm)	Rain fall (mm)
		Max.	Min.	Mean				
Sept. 2001	35	32.97	24.79	28.88	70.80	7.53	5.69	-
	36	33.39	25.07	29.23	70.64	6.67	5.10	-
	37	33.70	24.31	29.01	71.95	7.67	5.10	-
	38	36.31	25.50	30.91	65.83	9.61	6.47	-
Oct. 2001	39	37.16	24.83	31.00	62.31	8.03	6.23	-
	40	35.79	25.64	30.72	67.74	7.67	5.50	-
	41	34.64	25.10	29.87	75.01	5.34	4.29	41.40
	42	36.10	20.56	28.33	54.17	9.54	4.87	
Nov. 2001	43	37.07	17.39	27.33	50.62	9.91	4.74	-
	44	36.99	18.39	27.69	53.86	9.89	4.39	-
	45	34.27	16.21	25.24	48.25	9.87	4.99	-
	46	33.39	15.04	24.22	43.43	9.56	4.21	-
Dec. 2001	47	34.17	14.91	24.54	48.27	9.57	3.77	-
	48	30.17	12.57	21.64	52.17	9.57	3.71	-
	49	32.49	11.77	22.13	56.76	9.71	3.21	-
	50	31.09	13.00	22.05	57.05	9.24	3.24	-
	51	30.04	13.00	21.52	57.80	9.56	3.51	-

Month and year	Std. week	Temperature °C			Mean RH (%)	Sun-shine (hrs.)	Evapo-ration (mm)	Rain fall (mm)
Jan. 2002	52	29.23	11.74	20.49	50.37	9.39	3.50	-
	1	28.61	11.91	20.26	49.19	8.66	3.37	-
	2	29.67	12.37	21.02	54.53	9.33	3.69	-
	3	26.97	11.13	19.05	59.67	9.01	3.20	-
	4	26.46	9.94	18.20	62.07	9.34	3.77	-
Feb. 2002	5	27.01	9.94	18.48	46.43	9.67	4.90	-
	6	28.13	10.21	19.17	55.29	9.27	5.50	-
	7	30.49	13.50	22.50	62.35	10.01	5.86	-
	8	33.19	14.36	23.78	64.83	10.17	5.81	-
Mar. 2002	9	33.84	15.36	24.60	46.03	9.96	6.40	-
	10	34.17	16.60	25.39	46.91	9.51	6.61	-
	11	34.73	18.57	26.65	44.55	5.83	6.00	-
	12	38.91	18.79	28.85	42.39	9.74	8.33	-
	13	38.54	18.23	28.39	44.05	10.23	7.54	-

3.3 PHYSICO CHEMICAL CHARACTERISTICS OF SOIL

The physico-chemical properties of experimental plot were determined by drawing soil samples randomly before commencement of experiment from a depth of 0-15 cm and 15-30 cm and a composite sample was prepared and analyzed for physical and chemical properties of the soil. The values of soil analysis alongwith methods followed are furnished in Table 3.2.

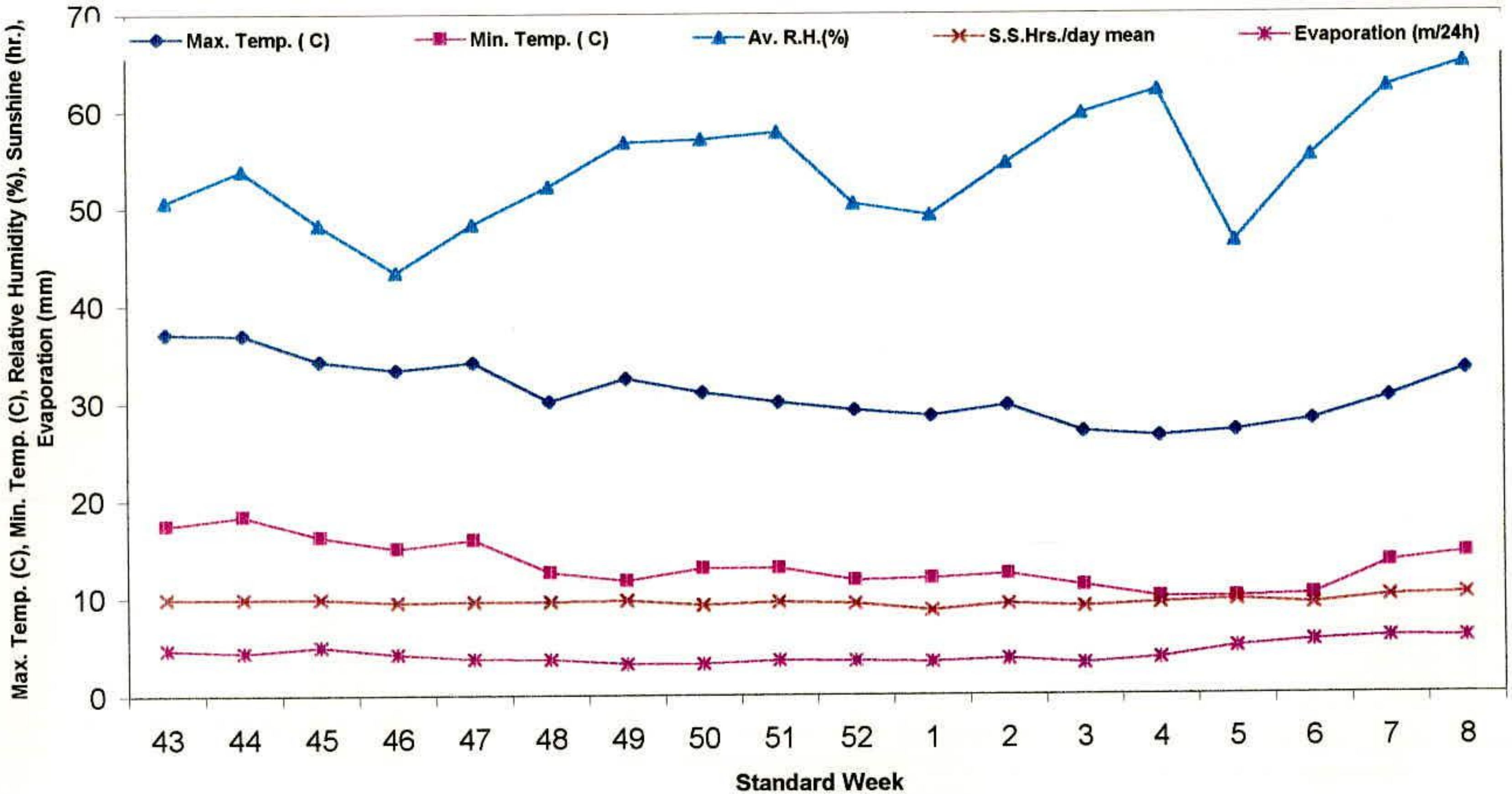


Fig. 3.1 : Mean weekly weather parameters recorded at the Meteorological Observatory, Anand during the crop season in the year 2001-2002

Table 3.2 : Physico-chemical properties of the experimental soil

Properties	Values at soil depth		Method adopted
	0-15 cm	15-30 cm	
(A) Physical properties			
Coarse sand (%)	0.5	0.49	International Pipette Method (Piper, 1966)
Fine sand (%)	82.00	83.2	"
Silt (%)	11.55	10.56	"
Clay	5.00	4.85	"
Field capacity (%)	16.00	16.00	Actual field Method
Permanent wilting point (%)	5.0	5.0	Sunflower Method)
Textural class	Sandy loam		(Dastane, 1972)
(B) Chemical properties			
Organic carbon (%)	0.38	0.4	Walkly and Black Method (Jackson, 1973)
Total nitrogen (%)	0.036	0.034	Kjeldahl's method (Jackson, 1973)
Available P_2O_5 (kg/ha)	42.5	41.9	Olsen's Method (Chopra and Kanwar, 1976)
Available K_2O (kg/ha)	602.00	532.8	Flame photometric Method (Jackson, 1973)
Soil pH (1:2.5, Soil : Water ratio)	7.9	8.0	Backman pH meter (Jackson, 1973)
Electrical conductivity (dSm^{-1} 25 °C)	0.25	0.28	Conductivity meter (Jackson, 1973)

The soil is representative of the soils of the region and is locally known as "Goradu" soil. The texture of the soil is sandy loam. The soil is very deep and fairly moisture retentive. This soil responds well to manuring and irrigation. It is suitable for variety of crops of tropical and sub-tropical regions. The ground water table being more than 10 m. in depth. Hence, there is no problem of high water table in the area.

3.4 CROPPING HISTORY OF EXPERIMENTAL PLOT

The details regarding the cropping history in respect of crop grown and fertilizer applied to the experimental plot during the two years preceding, the present investigation is presented in Table 3.3.

Table 3.3 : Cropping history of experimental plot

Year	Season	Crop	Fertilizer (kg/ha)		
			N	P_2O_5	K_2O
1999-2000	*Kharif*	Sannhemp	-	-	-
	Rabi	Mustard	100	50	50
	Summer	-	-	-	-
2000-2001	*Kharif*	Sannhemp	-	-	-
	Rabi	Mustard	100	50	50
	Summer	-	-	-	-
2001-2002	*Kharif*	Sunnhemp	-	-	-
	Rabi	Peas	20	75	35

3.5 CROP AND VARIETY

Peas (*Pisum sativum* L.) variety Arkel was selected for the present investigation. This variety was released by IARI, New Delhi. The details of these variety are presented as under

Sr. No.	Characters	Description
1.	Plant height (cm)	40
2.	Maturity (days)	60
3.	Branching per plant	8
4.	Pods per plant	12
5.	Seed size	Medium bold
6.	Seed colour	Green
7.	Protein content (%)	7.2
8.	Pod yield (kg ha^{-1})	6000-7000

3.6 EXPERIMENTAL DETAILS

The details of the experimental technique employed for the investigation on "Effect of weed management practices and *Rhizobium* inoculation on growth and yield of peas (*Pisum sativum* L.)" described hereafter.

3.6.1 Experimental treatments

The details of treatments are as under

(A) *Rhizobium* inoculation (R) : Two

R_1 With *Rhizobium* inoculation

R_2 Without *Rhizobium* inoculation

(B) Weed management practices (W) : Eight

W_1	Fluchloralin	@ 0.45 kg/ha
W_2	Fluchloralin	@ 0.90 kg/ha
W_3	Pendimethalin	@ 0.5 kg/ha
W_4	Pendimethalin	@ 0.75 kg/ha
W_5	Alachlor	@ 0.6 kg/ha
W_6	Alachlor	@ 1.2 kg/ha
W_7	Hand Weeding	15, 30 DAS
W_8	Weedy check	

Treatment combinations

Sr. No.	Treatment symbol	Sr. No.	Treatment symbol
1.	R_1W_1	9.	R_2W_1
2.	R_1W_2	10.	R_2W_2
3.	R_1W_3	11.	R_2W_3
4.	R_1W_4	12.	R_2W_4
5.	R_1W_5	13.	R_2W_5
6.	R_1W_6	14.	R_2W_6
7.	R_1W_7	15.	R_2W_7
8.	R_1W_8	16.	R_2W_8

Table 3.4 : Techniques adopted in chemical analysis

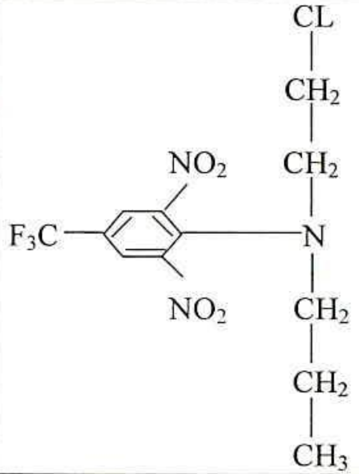
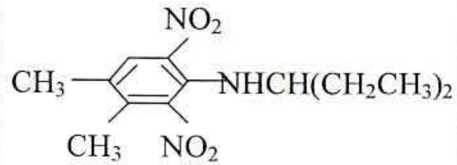
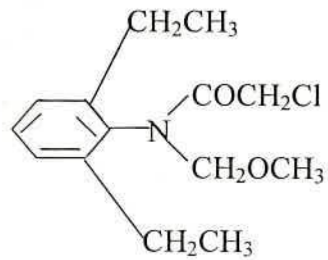
Sr. No.	Estimation of constituent	Methods adopted
1.	Nitrogen content in soil and weed	Micro kjeldhal's digestion and distillation method (Jackson, 1973)
2.	Phosphorus content in soil and weed	Olsen's method (Chopra and Kanwar, 1976)
3.	Potassium content in soil and weed	Flame photometric method (Jackson, 1973)
4.	Protein content in seed	Micro kjeldhal's digesting and distillation method (Jackson, 1973) Protein content = % N x 6.25

Accordingly the required quantity of herbicide formulation was determined by the formula for different herbicidal treatments and are as under (Table 3.5).

Table 3.5 : Herbicide manufacture application rate (kg/ha), required quantity (ml) and company

Sr. No.	Herbicide	Trade product	Herbicide application rate (kg/ha)	Required quantity (ml.) of trade product for 18.0 m^2	Manufactured or marketed by
1.	Fluchloralin	Basalin 45 EC	0.45 0.90	1.8 3.6	BASF India Ltd.
2.	Pendimethalin	Stomp 30 EC	0.50 0.75	3.0 4.5	BASF India Ltd.
3.	Alachlor	Lasso 50 EC	0.60 1.2	2.16 4.32	Monsanto Chemicals India Ltd.

Table 3.6 : The particulars of herbicides used

Sr. No.	Particulars	Fluchloralin	Pendimethalin	Alachlor
1.	Manufacturer	BASF India Ltd. Mumbai-400 025	BASF India Ltd. Mumbai-400 025	Monsanto Enterprises Pvt. Ltd.
2.	Trade name and formulation	Basalin 45% EC	Stomp 30% EC	Lasso 50%
3.	Chemical name	N-(2-chloroethyl)-2,6 dinitro-N-propyl-4(trifluoromethyl) benzenamine	N-(1-ethylpropyl)-3,4-dimethyl-2, 6-dinitrobenzenamine	2-chloro-N-(2, 6-diethylphenyl)-N-(methoxymethyl) acetamide
4.	Chemical structure			
5.	Solubility in water	1 mg/l (20 °C)	0.3 mg/l (20 °C)	242 mg/l (25 °C)
6.	Group	Dinitroanilines (Anilines and nitro-phenols)	Dinitroanilines (Anilines and nitro-phenols)	Chloroacetanilide
7.	Melting point	42-43 °C	54-58 °C	39.5 – 41.5 °C
8.	Acute oral LD_{50} for rats	1550 mg/kg	2930 mg/kg	1800 mg/kg

Sr. No.	Particulars	Fluchloralin	Pendimethalin	Alachlor
9.	**Applications** Mode of action	Selective herbicide absorbed via shoots and roots, with acropetal movement throughout the entire plant. Affects seed germination and other physiological growth processes, especially in the radicle (Tomlin, 1994).	Selective herbicide, absorbed by the roots and leaves. Inhibits cell division and cell elongation. Affected plants die shortly after germination or following emergence from the soil (Tomlin, 1994).	Selective systemic herbicide, absorbed principally by germinating shoots, but also by the roots, with translocation throughout the plant, and accumulation mainly in vegetative parts rather than in reproductive parts. Acts by inhibition of protein synthesis and root elongation.
	Uses	Control of annual grasses and some broad-leaves weeds in cotton, rice (transplanted), soya beans, peanuts, snap beans, lima beans, okra, jute, sunflowers, potatoes, and several vegetable crops. Applied pre-plant or pre-emergence with soil incorporation.	Control of most annual grasses and many annual broad-leaves weeds in cereals, onions, leeks, garlic, fennel, maize, sorghum, rice, soya beans, peanuts, brassicas, carrots, celery, black salsify, peas, field beans, lupins, evening primrose, tulips, potatoes, cotton, hops, pome fruit, stone fruit, berry fruit (including strawberries), citrus fruit, lettuce, aubergines, capsicums, established turf, and in transplanted tomatoes, sunflowers, and tobacco. Applied pre-plant incorporated, pre-emergence, pre-transplanting, or early post-	Used pre-emergence to control annual grasses and many broad-leaved weeds in cotton brassicas, maize, oilseed rape, peanuts, radish, soyabeans and sugarcane. It is mainly absorbed by germinating shoots, secondarily by roots. It is translocated throughout the plant mainly to vegetative rather than to reproductive organs. It is rapidly metabolised in plants (Tomlin, 1994).

			emergence. Also used for control of suckers in tobacco,	
Sr. No.	Particulars	Fluchloralin	Pendimethalin	Alachlor
10.	**Environmental Fate** Soil and Water	In soil, strongly adsorbed by clay colloids and organic matter, with no leaching. Dealkylation occurs to N-(2-chloroethyl)-, N-propyl-, and unsubstituted trifluoro-2,6-dinitro-p-toluidine and to cyclised products. In u.v. light, there is also reduction of the nitro group to an amino group. Low level soil residues may persist for more than one season after application and phytotoxicity to very sensitive crops may occur.	In soil, the 4-methyl group on the benzene ring is oxidised to the carboxylic acid via the alcohol; the amino nitrogen is also oxidised. DT_{50} in soil is 3-4 months (A. Walker and W. Bond *Pestic. Sci.*, 1977, **8**, 359). Adsorption Freundlich K *c*. 37.	Rapidly degraded in soil by microbial action to 2',6'-diethyl, with further degradation to the aniline derivative. Persists in soil for *c*. 6-10 weeks (J. Tiedie *et al*., *J. Agric. Food Chem.* 1975, **23**, 77; J.K. Lee Hanguk Nanghwa Hakhoechi 1986, **29** 182; *Rev. Environm. Contam. Toxicol.* 1989, **110**, 110-114.

3.6.2 Experimental design and layout

1.	Design : FRBD (Factorial Randomized Complete Block Design)		
2.	Number of replication	:	Four (4)
3.	Number of treatment combinations	:	16
4.	Number of total plots	:	64
5.	Plot size	:	Gross : 5.0 m x 3.6 m
			Net : 4.0 m x 3.0 m
6.	Spacing between two rows	:	30 cm
7.	Seed rate	:	120 kg/ha
8.	Crop and variety	:	Pea, Arkel

3.7 CULTURAL OPERATIONS

A schedule of cultural operations followed during entire crop season is presented in Table 3.7.

3.7.1 Preparation of land

The experimental field was cross cultivated by tractor drawn cultivator. Stubbles of the previous crop were collected and removed from the field. Planking was done in both the directions to develop a fine tilth. The layout of experiment was done as per design employed.

3.7.2 Fertilizer application

Furrows were opened manually in each plot keeping spacing of 30 cm in between two rows. Required quantity of nitrogen, phosphorus and potash were weighed for each treatment and applied in

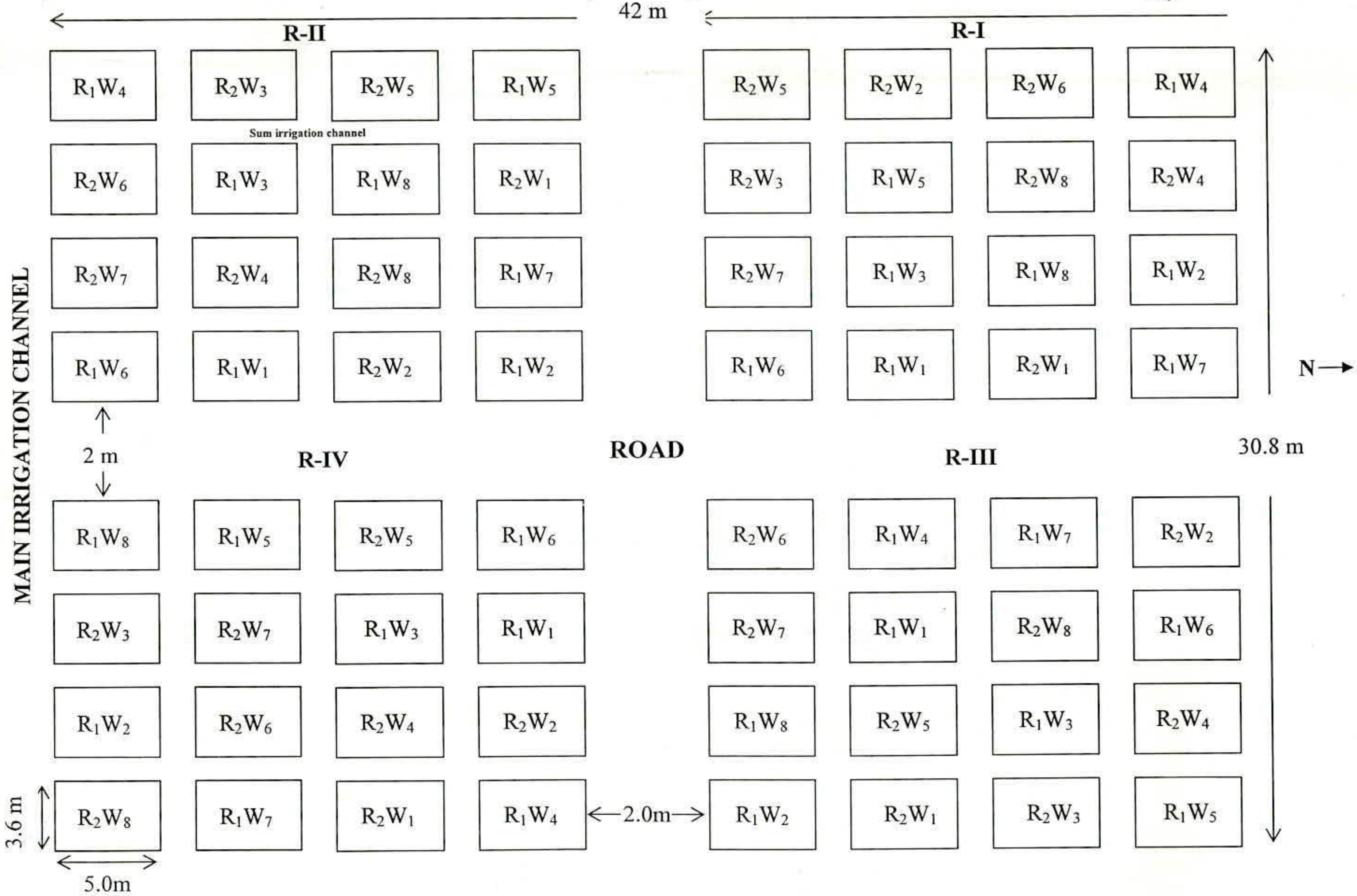


Fig. 3.2 : Layout plan of the experimental field

soil about 5 to 6 cm deep just before sowing of seeds in the previously opened furrows and the furrows were slightly cover with the soil thoroughly.

Table 3.7 : Calendar of operations carried out during the experimental period

Sr. No.	Cultural operations	Frequency	Date
(A)	**Pre-sowing operations**		
1.	Tractor cultivation (cross wise), Harrowing and planking	One	01-11-2001
2.	Field layout	One	22-11-2001
3.	Opening of furrows for fertilizer application	One	27-11-2001
4.	Application of N, P_2O_5 and K_2O as basal dose	One	27-11-2001
5.	Seed treatment with *Rhizobium* culture	One	27-11-2001
6.	Preparation of beds and irrigation channel	One	27-11-2001
(B)	**Sowing and post-sowing operations**		
1.	Sowing of seeds in furrow by dibbling	One	27-11-2001
2.	First irrigation immediately after sowing	One	27-11-2001
3.	Herbicide treatment	One	29-11-2001
4.	Weeding (HW 15,30 DAS)	One One	13-12-2001 29-12-2001
5.	Irrigation	1st 2nd 3rd 4th 5th 6th	27-11-2001 12-12-2001 26-12-2001 10-01-2002 22-01-2002 31-01-2002
6.	Plant protection Equalux 25 EC (Quinalphos) Endosel 35 EC (Endosulphan)	 One One	 08-01-2002 25-01-2002
7.	Picking	1st 2nd 3rd 4th	22-01-2002 29-01-2002 05-02-2002 12-02-2002
8.	Harvesting Weed sample collection Crop harvesting	 One One	 13-02-2002 18-02-2002

3.7.3 Seeds and sowing

Certified seeds of pea variety Arkel were used for sowing. Before sowing the required quantity of seeds were treated uniformly with *Rhizobium* culture and drying of inoculated seeds was done under the shade, for sowing of all inoculated treatments. Remaining quantity of seeds which was not treated with *Rhizobium* culture was used for sowing of uninoculated treatment. Sowing was done under dry condition on 27th November, 2001 with a recommended seed rate of 120 kg ha^{-1} in each plot. The seeds were sown manually at 3-4 cm depth keeping inter row spacing of 30 cm in the same pre-opened furrows of each plot.

3.7.4 Herbicide application technique

Application of herbicides was done at one day after sowing. The required quantity of trade formulation of each herbicide for plot of 18.0 m^2 was calculated by using the following formula.

$$Rh = \frac{Ai \times At}{Ci} \times 100$$

Where,

Rh = Required quantity of trade formulation of herbicide (lit/ha)

Ai = Quantity of active ingredient to be applied (kg)

At = Area to be treated (ha)

Ci = Concentration of active ingredient in the trade formulation

Enough quantity of water required for each plot was taken and measured herbicide thoroughly mixed. The spraying was done with the help of knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. The particulars of chemicals tested in this study are given in the Table 3.6.

3.7.5 Irrigation

The first light irrigation was given to the crop immediately after dibbling the seeds for uniform germination of seeds. The total six irrigation were given to the crop when dry scale was observed in the field.

3.7.6 Cultural weed management

Two hand weedings were carried out in W_7 treatment (weed free) at 15 and 30 days after sowing (DAS).

3.7.7 Plant protection

Prophylatic measures were taken against the pea pests by spraying of Equalux 25 EC (Quinalphos) Endosel 35 EC (Endosulfan).

3.8 BIOMETRIC OBSERVATIONS

The biometric observations were recorded from five randomly selected plants tagged within each net plot. The various growth parameters, yield attributes, quality and chemical parameters were studied during the course of investigation. Details of the techniques followed for recording the observations are described below.

3.8.1 Germination (%) and plant population studies

For germination and plant population studies, number of plants per meter row length of the crop was ascertained at five spots selected randomly in each net plots. Germination (%) was recorded at 10 DAS, while the plant population was recorded at 20 DAS. The data for germination were converted in percentage and were analyzed statistically.

3.8.2 Growth parameters studied

3.8.2.1 Plant height (cm)

Plant height was recorded at 30 DAS and at harvest for five randomly selected plants in each net plot and average was calculated and recorded separately.

3.8.2.2 Number of nodules per plant

Observation of number of nodules per plant was taken on 50 DAS. Five plants from each net plot were randomly selected for this purpose. The plants were dug out with the help of kudali. Sufficient care was taken, so that entire root system of the plant could be removed from the soil without any injury to nodules. Root portion of plant was kept in water filled in a bucket to wash out soil particles from the root portion. Thereafter, individual nodules were separated from the root portion and counted for each plot. The average number of nodules per plant were recorded treatment wise.

3.8.2.3 Dry weight of nodules per plant (mg)

The dry weight of root nodules per plant were taken and mean value was calculated for each plot.

3.8.3 Yield and yield attributes

3.8.3.1 Number of pods per plant

The total number of developed pods from previously five tagged plants at the time of different picking were counted and their average value per plant was worked out and recorded for each treatment.

3.8.3.2 Number of seeds per pod

The total number of seeds from the pods of previously selected plants were counted and their average value was worked out and recorded for each treatment.

3.8.3.3 Total green pod yield (kg/ha)

The sum of the green pod yield at different picking was done to get the green pod yield in kg ha^{-1}.

3.9 CALCULATIONS MODE

3.9.1 Weed control efficiency (WCE)

Weed control efficiency (WCE) was calculated by using formula suggested by Mani *et al.* (1973).

$$WCE = \frac{DWC - DWT}{DWC} X 100$$

Where,

WCE = Weed control efficiency

DWC = Dry weight of weeds in control plot (Weedy check)

DWT = Dry weight of weeds in treated plot

3.9.2 Weed index (W_1)

The yield reduction (%) owing to the presence of weeds was estimated by using the formula developed by Gill and Kumar (1969) and expressed as weed index (%).

Where,

$$W_1 = \frac{x - y}{x} \times 100$$

W_1 = Weed index in per cent

x = Yield from weed free plot

y = Yield from the treatment for which weed index is to be estimated

3.9.3 Harvest index (%)

Harvest index is the ratio of economic yield to the biological yield per plot. It was calculated by using following formula (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Above ground biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.10 PLANT ANALYSIS

Plant analysis pertaining to nutrients (NPK) uptake by crop and weeds as well as protein content in seeds were done as described as under.

3.10.1 Nutrients uptake (NPK)

Representative samples of crop and weeds collected from each net plot at the time of harvest were used for chemical analysis. An oven dried samples were powdered separately in a wiley mill for analysis in respect of N, P and K content by standard methods. Plant materials were digested in a mixture of conc. HN_03, H_2SO_4 and 60% $HCLO_4$ in a ratio of 10:4:1 (Piper, 1966). Estimation of total nitrogen was made by modified kjeladahl's method as described by Jackson (1973). Estimation of phosphorus was made by Olsen's method (Jackson, 1973). Estimation of potassium was made from acid extract by Flame photometric method as described by Jackson (1973).

$$\text{Nutrient uptake by weeds (kg/ha)} = \frac{\text{\% nutrient content X Weed biomass at harvest (kg/ha)}}{100}$$

3.10.2 Protein content at different picking

Seed samples were prepared from the produce of each of the experimental plots and nitrogen content was determined by the standard kjeldhal's method (Jackson, 1973). Protein content in each of the sample was derived by multiplying the nitrogen percentage in seeds by 6.25 (Table 3.5).

3.11 ECONOMICS

In order to evaluate the effectiveness of each individual treatments, the relative economics of each treatment combination was worked out in terms of net profit, so that the most effective and remunerative treatment combination could be found out. The gross realization in terms of rupees per hectare was calculated from the pod yield at the prevailing market price during the course of investigation. The cost of cultivation was worked out considering the cost of all operations right from the cost of preparation of land to the harvesting of the crop and the cost of all inputs involved. The net realization was worked out by deducting the total cost of cultivation from the gross realization per hectare for each treatment combinations and recorded accordingly. The CBR was calculated on the basis of formula.

3.12 STATISTICAL ANALYSIS

Statistical analysis of the data of various characters studied in the investigation was carried out through the statistical analysis of variance techniques as described by Panse and Sukhatme (1967) using the Computer facilities at the Computer Centre, B. A. College of Agriculture, Gujarat Agricultural University, Anand. The significance of treatment differences was tested employing 'F' test. Five per cent level of significance was used to test the significance of results. The critical differences were calculated when differences among the treatments were found significant by 'F' test. In remaining cases only standard error of mean were worked out. The co-efficient of variation (CV %) was also worked out.

3.13 CORRELATION STUDIES

With a view to determine the relationship, if any, between yield alongwith it's attributes and weed parameters in pea crop, simple correlation coefficients (r) were worked out as per the procedure given (Snedecor and Cochran, 1967).

RESULTS

IV. RESULTS

A field experiment was carried out during the *Rabi* season of 2001-2002 to study the "Effect of weed management practices and *Rhizobium* inoculation on growth and yield of peas [*Pisum sativum* L.]". Data obtained in this investigation are presented alongwith statistical inferences in this chapter. The results of various analysis of the different parameters are presented in main heads as under:

4.1 Effect of treatments on weeds

4.2 Effect of treatments on growth and yield attributes of peas

4.3 Effect of treatments on yield and quality

4.4 Economics of different treatments

4.5 Correlation studies

4.1 EFFECT OF TREATMENTS ON WEEDS

4.1.1 The weed flora

The weed flora noted in the experimental plots is detailed in Table 4.1 accordingly to their scientific name, English name, local name, family and nature of cotyledons. Among monocot weeds two species were perennial *viz*., *Cyperus rotundus* L. and *Cynodon dactylon* (L.) Pers and

Plate I : General view of experimental site other monocot weed species were annual. While in dicot weeds all the species were annual.

Table 4.1 : Weed flora of the experimental area

Sr. No.	Scientific name	English name	Local name	Family
	Monocot weeds			
1.	*Cyperus rotundus* L.	Purple nut sedge	Chidho	Cyperaceae
2.	*Cyperus iria* L.	Rice sedge	Chidho (Didiu)	Cyperaceae
3.	*Cyperus esculentus* L.	Purple nut sedge	Chidho (Dilo)	Cyperaceae
4.	*Cynodon dactylon* L. Pers	Barmuda grass	Dharo	Chlorideae
5.	*Digitaria sanguinalis* L. Scop.	Large crab	Arotaro	Paniceae
6.	*Eragrostis major P. Beauv*	Love grass	Bhumsi	Festocaceae
7.	*Eleusine indica* L. Gaertn	Goose grass	Chokhaliu	Chlorideae
	Dicot weeds			
1.	*Phyllanthus niruri* L.	Gripe weed	Bhoiambali	Euphorbiaceae
2.	*Euphorbia hirta* L.	Spurge	Dudheli	Euphorbiaceae
3.	*Boerhavia diffusa* L.	Creeping spiderling	Satodi	Nyctaginaceae
4.	*Commelina banghalensis* L.	Commelin	Semul	-
5.	*Gisekia pharnaceoides L.*	-	Gisekia	Mollugi-naceae

Plate IX : Monocot weed species of the experimental plot

1. *Cynodon dactylon* L.
2. *Cyperus rotundus* L.
3. *Cyperus iria* L.
4. *Cyperus esculentus* L.
5. *Digitaria sanguinalis* L.
6. *Eragrostis major* P.
7. *Eleusine indica* L.

Plate X : Dicot weed species of the experimental plot

1. *Phyllanthus niruri* L.
2. *Euphorbia hirta* L.
3. *Boerhavia diffusa* L.
4. *Commelina baghalensis* L.
5. *Gisekia pharnaceoides* L.

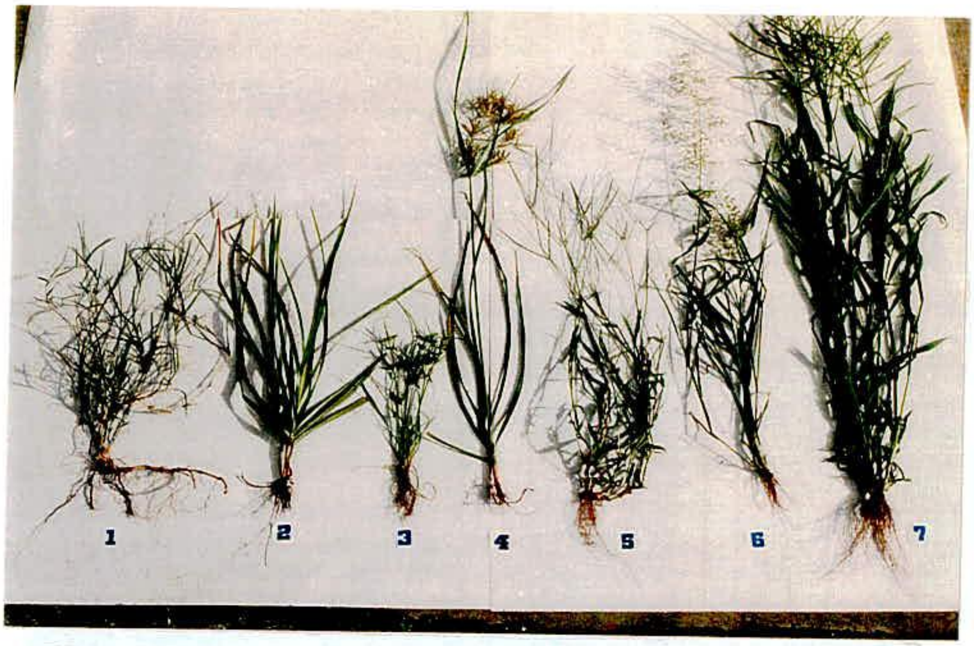


Plate IX : Monocot weed species of the experimental plot

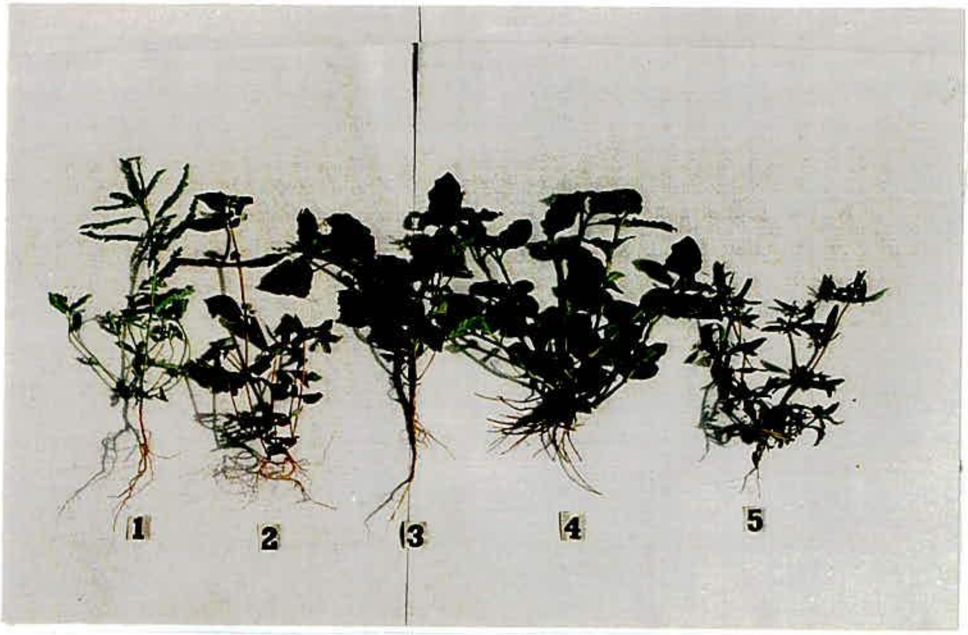


Plate X : Dicot weed species of the experimental plot

4.1.2 Weeds count at 20 DAS

Data on weed count/m^2 recorded at 20 DAS as influenced by different weed management practices and *Rhizobium* inoculation and their interaction effects are presented in Table 4.2.

4.1.2.1 Effect of weed management practices

A perusal of data (Table 4.2) showed that the differences due to different weed management practices were significant with respect to weeds/m^2 at 20 DAS. Significantly the lowest weeds were recorded under treatment W_7 (4.27/m^2) which was at par with treatment W_4 (5.00/m^2). The maximum weeds were recorded under treatment W_8 (8.41/m^2) which was statistically at par with treatments W_5 (7.95/m^2) and W_6 (7.69/m^2).

4.1.2.2 Effect of *Rhizobium* inoculation

It was observed from the data given in Table 4.2 that the differences due to *Rhizobium* inoculation treatments were non-significant with respect to weeds count/m^2 at 20 DAS.

4.1.2.3 Interaction effect

The interaction effect was found to be non-significant.

4.1.3 Weeds count at 40 DAS

Data on weed count/m^2 recorded at 40 DAS as influenced by *Rhizobium* inoculation, weed management practice and their interaction are presented in Table 4.2.

Table 4.2 : Weeds count/m^2 recorded at 20, 40 DAS and at harvest as influenced by different weed management and *Rhizobium* inoculation treatments

Treatment	Weeds count/m^2		
	at 20 DAS	at 40 DAS	at harvest
***Rhizobium* inoculation (R)**			
R_1 = With *Rhizobium* inoculation	6.72	7.90	10.76
R_2 = Without *Rhizobium* inoculation	6.34	8.41	10.48
S.Em. ±	0.141	0.33	0.21
CD (0.05)	NS	NS	NS
Weed management practices (W)			
W_1 : Fluchloralin 0.45 kg/ha	7.15	6.97	8.95
W_2 : Fluchloralin 0.90 kg/ha	6.70	6.91	9.32
W_3 : Pendimethalin 0.50 kg/ha	5.11	4.56	6.92
W_4 : Pendimethalin 0.75 kg/ha	5.00	4.38	6.64
W_5 : Alachlor 0.60 kg/ha	7.95	11.77	13.41
W_6 : Alachlor 1.20 kg/ha	7.69	10.72	14.36
W_7 : HW 15,30 DAS	4.25	3.00	5.52
W_8 : Weedy check	8.41	16.93	19.82
S.Em. ±	0.282	0.667	0.418
CD (0.05)	0.80	1.89	1.18
R x W interaction	NS	NS	S
CV %	12.19	23.12	11.14

4.1.3.1 Effect of weed management practices

The results presented in Table 4.2 revealed that weeds count/m^2 were significantly influenced due to different weed management practices at 40 DAS. Among all the treatments, significantly lower number of weeds were recorded under the treatment W_7 (3.00/m^2) which was at par with treatments W_4 (4.38/m^2) and W_3 (4.56/m^2). Treatment W_8 recorded significantly the highest number of weeds (16.93/m^2) when compared to all other treatments.

4.1.3.2 Effect of *Rhizobium* inoculation

It was observed from the data given in Table 4.2 that the differences due to *Rhizobium* inoculation treatments were non-significant with respect to weeds count/m^2 at 40 DAS.

4.1.3.3 Interaction effect

The interaction effect was non-significant (Table 4.2).

4.1.4 Weed count at harvest

Data on weeds count/m^2 recorded at harvest as influenced by different weed management practices, *Rhizobium* inoculation and their interaction are presented in Table 4.2.

4.1.4.1 Effect of weed management practices

Data on weeds count/m^2 at harvest were significantly influenced due to different weed management practices (Table 4.2). Among all the treatments, treatment W_7 recorded minimum weeds count/m^2 (55.52/m^2) which was statistically at par with treatment W_4 (6.64/m^2). The maximum weeds count/m^2 was recorded for the treatment W_8 (19.82/m^2).

4.1.4.2 Effect of *Rhizobium* inoculation

The effect of *Rhizobium* inoculation on weeds count/m^2 at harvest was found to be non-significant (Table 4.2).

Table 4.3 : Weed count/m^2 as influenced by R x W interaction

Weed management practices (W)	*Rhizobium* inoculation	
	R_1	R_2
W_1	9.02	8.87
W_2	9.27	9.37
W_3	7.15	6.70
W_4	6.87	6.40
W_5	14.27	12.55
W_6	13.00	15.72
W_7	6.05	5.00
W_8	20.42	19.22
S.Em.	0.592	-
C.D.	1.67	-

4.1.4.3 Interaction effect

The results revealed that interaction R x W was significant with respect to weeds count/m^2 at harvest. For both the cases with or without *Rhizobium* inoculation, treatment W_7 recorded minimum weeds count, which was at par with those of W_4 and W_3. The maximum weeds count/m^2 was recorded by W_8 in both the cases.

4.1.5 Dry weight of weeds at harvest

Data on dry weight of weeds recorded at harvest as influenced by different weed management practices and *Rhizobium* inoculation are presented in Table 4.4 and graphically depicted in Fig. 4.1.

4.1.5.1 Effect of weed management practices

Data presented in Table 4.4 revealed that dry weight of weeds recorded at harvest were significantly affected by different weed management practices. Treatment W_7 registered significantly lower dry weight of weeds at harvest (136.87 kg/ha) which was found to be at par with treatments W_3 (522.29 kg/ha) and W_4 (585.10 kg/ha). Treatment W_8 recorded significantly the highest dry weight of weeds (4881.56 kg/ha).

4.1.5.2 Effect of *Rhizobium* inoculation

The effect of different treatments of *Rhizobium* inoculation on dry weight of weeds at harvest were found to be non-significant (Table 4.4).

4.1.5.3 Interaction effect

The interaction effect was found to be non-significant (Table 4.4).

Table 4.4: Dry weight of weeds recorded at harvest as influenced by different weed management practices and *Rhizobium* inoculation

Treatment	Dry wt. of weeds kg/ha	WCE (%)
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	2138.70	56.2
R_2 = Without *Rhizobium* inoculation	2173.50	55.5
S.Em. $\pm$	133.94	-
CD (0.05)	NS	-
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	3047.29	37.6
W_2 : Fluchloralin 0.90 kg/ha	2143.75	56.1
W_3 : Pendimethalin 0.50 kg/ha	522.29	89.3
W_4 : Pendimethalin 0.75 kg/ha	585.10	88.0
W_5 : Alachlor 0.60 kg/ha	3465.83	29.0
W_6 : Alachlor 1.20 kg/ha	2466.04	49.5
W_7 : HW 15,30 DAS	136.87	97.2
W_8 : Weedy check	4881.56	-
S.Em. $\pm$	267.88	-
CD (0.05)	757.69	-
R x W interaction	NS	-
CV %	35.14	-

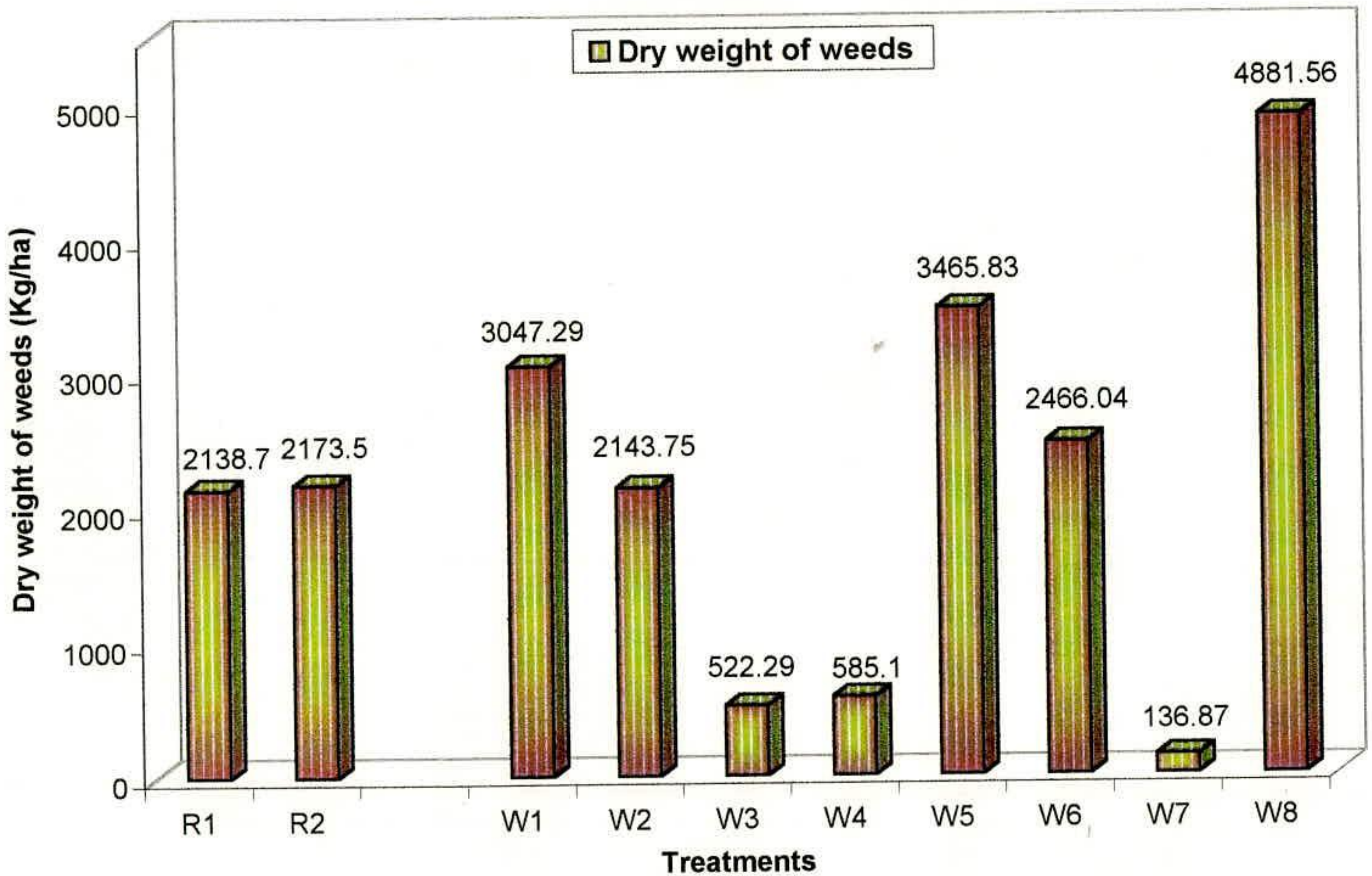


Fig. 4.1 : Total dry weight of weeds (Kg/ha) at harvest as influenced by weed management practices and *Rhizobium* inoculation treatmetns

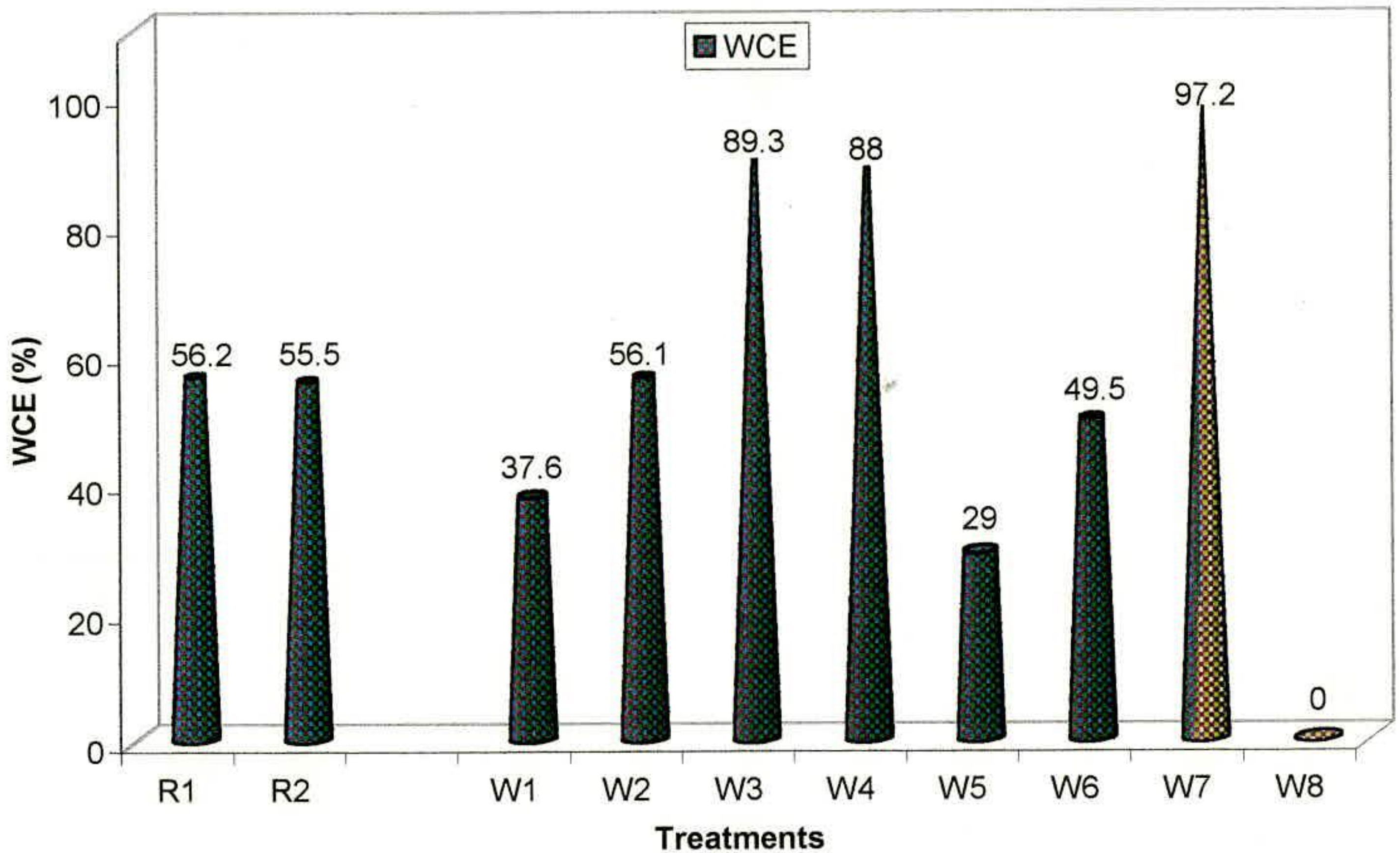


Fig. 4.2: Weed control efficiency (%) as influenced by different weed management practices and *Rhizobium* inoculation treatments

Plate II : Pendimethalin at 0.5 kg/ha was effective for controlling weeds

Plate III : The plot is fully infested by weeds under control plot

4.1.6 Weed control efficiency (%)

Weed control efficiency (WCE) worked out based on dry weight of weeds recorded at harvest under different treatments are furnished in Table 4.4 and graphically depicted in Fig. 4.2.

An appraisal of data on weed control efficiency indicated that among *Rhizobium* inoculation treatments weed control efficiency for R_1 and R_2 was 56.2% and 55.5%, respectively.

Among different weed management practices, maximum weed control efficiency was recorded under treatment W_7 (97.2%) followed by treatments W_3 (89.3%) and W_4 (88.0%). The lowest weed control efficiency was recorded under treatment W_5 (29.0%).

4.1.7 Nutrient content in weed (%)

Data pertaining to nutrient content (nitrogen, phosphorus and potash) in weeds are presented in Table 4.5.

4.1.7.1 Effect of *Rhizobium* inoculation

It was observed from the data given in Table 4.5 that the differences due to *Rhizobium* inoculation was significant with respect to N content in weed. Significantly higher value of N content of weed was recorded under the treatment R_1 (3.83%) as compared to R_2 (3.44%).

The differences due to *Rhizobium* inoculation was non-significant with respect to P_2O_5 content in weed. However, the higher value

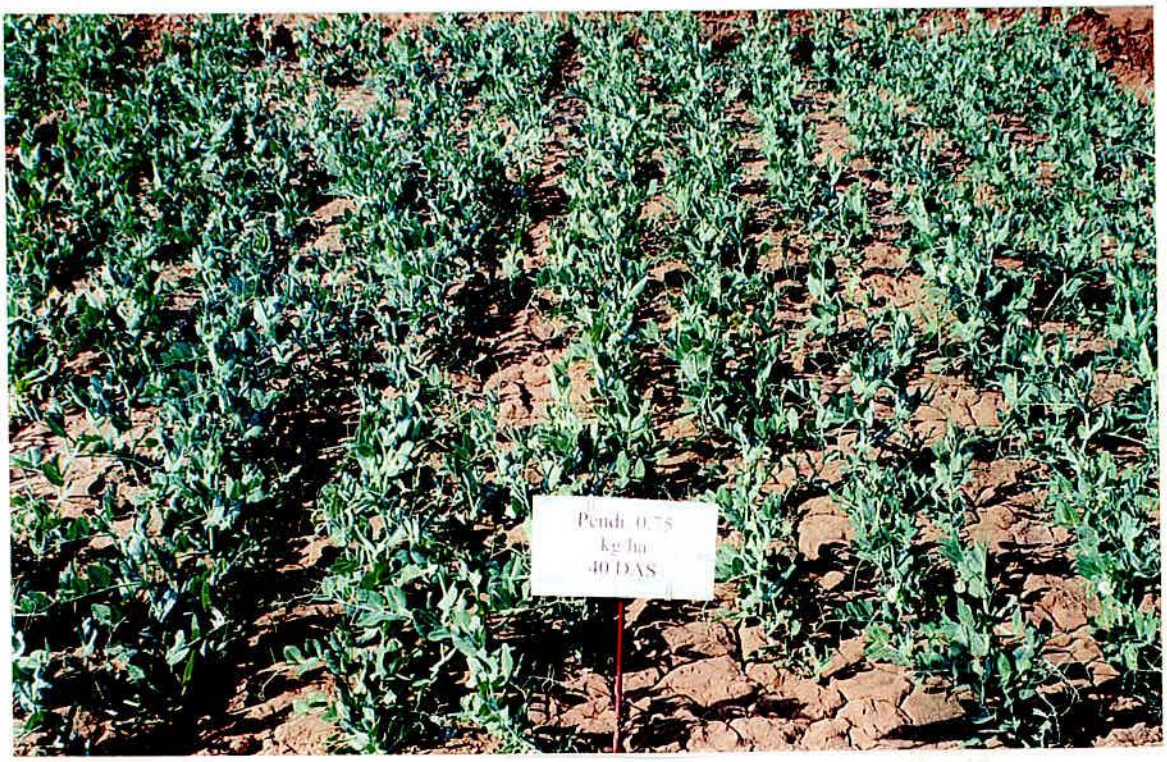


Plate IV : The reduction in weed intensity in pendimethalin at 0.75 kg/ha

of P_2O_5 content of weed was recorded under the treatment R_1 (0.92%) as compared to R_2 (0.86%) but statistically they are not significant.

The differences due to *Rhizobium* inoculation was non-significant with respect to K_2O content in weed. However, the higher value of K_2O content of weed was recorded under the treatment R_1 (4.75 %) as compared to R_2 (4.50 %) but statistically they are not significant.

4.1.7.2 Effect of weed management practices

Among all the treatments, W_4 (Pendimethalin 0.75 kg/ha) recorded minimum nitrogen content (2.80 %) in dry weed biomass. Treatment W_8 (weedy check) recorded maximum nitrogen content (5.38 %). The nitrogen content for treatment W_4 was at par with that of treatment W_3.

In case of phosphorus content by weed the treatment W_4 recorded the lowest P_2O_5 (0.71%) being at par with treatments W_7 (0.78 %), W_1 (0.81%), W_3 (0.82%), W_6 (0.87%) and W_2 (0.90%). So all the treatments showed less nutrient (P_2O_5) uptake by weeds except treatment W_5 (0.99%) as compared to weedy check (1.23%).

The variation was also observed in different weed management practices in K_2O content by weeds. The lowest K_2O uptake was recorded under treatment W_3 (3.55%) being followed by treatments W_4 (3.72%), W_7 (4.06%) and W_1 (4.22%). Weedy check recorded the highest K_2O uptake by weeds (6.24 %).

Table 4.5: Major nutrients content (%) of weeds at harvest as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Nutrient content in weed (%)		
	N	P_2O_5	K_2O
***Rhizobium* inoculation (R)**			
R_1 = With *Rhizobium* inoculation	3.83	0.92	4.57
R_2 = Without *Rhizobium* inoculation	3.44	0.86	4.50
S.Em. ±	0.073	0.038	0.148
CD (0.05)	0.21	NS	NS
Weed management practices (W)			
W_1 : Fluchloralin 0.45 kg/ha	3.70	0.81	4.22
W_2 : Fluchloralin 0.90 kg/ha	3.91	0.90	4.46
W_3 : Pendimethalin 0.50 kg/ha	2.89	0.82	3.55
W_4 : Pendimethalin 0.75 kg/ha	2.80	0.71	3.72
W_5 : Alachlor 0.60 kg/ha	3.69	0.99	4.82
W_6 : Alachlor 1.20 kg/ha	3.67	0.87	5.21
W_7 : HW 15,30 DAS	3.03	0.78	4.06
W_8 : Weedy check	5.38	1.23	6.24
S.Em. ±	0.145	0.077	0.297
CD (0.05)	0.41	0.22	0.84
R x W interaction	NS	NS	S
CV %	11.31	24.4	18.51

4.1.7.3 Interaction effect

The interaction effect of *Rhizobium* inoculation and weed management practices in nitrogen and phosphorus content by weeds was found to be non-significant while in case of potassium content by weeds at harvest was significant.

Table 4.6: K_2O content (%) as influenced by R x W interaction

Weed management practices (W)	*Rhizobium* inoculation (R)	
	R_1	R_2
W_1	4.17	4.27
W_2	4.19	4.73
W_3	2.93	4.17
W_4	3.27	4.17
W_5	5.32	4.31
W_6	6.11	4.30
W_7	4.41	3.70
W_8	6.14	6.34
S.Em.	0.42	-
CD (0.05)	1.19	-

For both the cases with or without Rhizobium inoculation, treatment W3 recorded minimum K_2O content. The maximum K_2O content was recorded by W_8 in both the cases. So, all the weed management practices and *Rhizobium* inoculation treatments were found to be effective except alachlor at both the rates 0.60 and 1.20 kg/ha.

4.1.8 Major nutrients depletion by weeds

Data pertaining to nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) uptake by weeds as influenced by different treatments at harvest are presented in Table 4.7.

4.1.8.1 Effect of *Rhizobium* inoculation

Statistical analysis of data pertaining to nitrogen uptake by weeds are presented in Table 4.7. Nitrogen removal by weeds under treatment R_1 was more (81.91 kg/ha) as compared to treatment R_2 (74.77 kg/ha).

In case of P_2O_5 removal by weeds, there was no much more difference found between treatment R_1 and R_2. Under treatment R_1 19.68 kg/ha P_2O_5 removal by weeds while under treatment R_2 18.69 kg/ha P_2O_5 removal by weeds.

In case of K_2O removal by weeds, treatment R_1 reported 97.74 kg/ha while treatment R_2 reported 97.80 kg/ha.

4.1.8.2 Effect of weed management practices

The data pertaining to nutrients uptake by weeds presented in Table 4.7 showed variation among different treatments.

Table 4.7 : Major nutrients (kg/ha) removal by weeds at harvest as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Nutrient removal by weed (kg/ha)		
	N	P_2O_5	K_2O
***Rhizobium* inoculation (R)**			
R_1 = With *Rhizobium* inoculation	81.91	19.68	97.74
R_2 = Without *Rhizobium* inoculation	74.77	18.69	97.80
Weed management practices (W)			
W_1 : Fluchloralin 0.45 kg/ha	112.75	26.68	128.59
W_2 : Fluchloralin 0.90 kg/ha	83.82	19.29	95.61
W_3 : Pendimethalin 0.50 kg/ha	15.10	4.28	18.54
W_4 : Pendimethalin 0.75 kg/ha	16.44	4.15	21.76
W_5 : Alachlor 0.60 kg/ha	127.89	34.31	167.05
W_6 : Alachlor 1.20 kg/ha	128.48	21.45	128.48
W_7 : HW 15,30 DAS	4.15	1.07	5.56
W_8 : Weedy check	262.63	60.04	304.61

All the weed control treatments reduced the nitrogen uptake by weeds. Treatment W_7 recorded minimum nitrogen uptake by weeds (4.15 kg/ha) which is followed by treatments W_3 (15.10 kg/ha), W_4 (16.44

kg/ha) and W_2 (83.82 kg/ha). The removal of nitrogen was greatest (262.63 kg/ha) in unweeded control.

All the weed control treatments reduce the phosphorus uptake by weeds. Treatment W_7 recorded minimum phosphorus uptake by weeds (1.07 kg/ha) which is followed by treatments W_4 (4.15 kg/ha), W_3 (4.28 kg/ha), W_2 (19.29 kg/ha) and W_1 (26.68 kg/ha). The removal of phosphorus was greatest (60.04 kg/ha) under treatment W_8 (unweeded control).

All the weed control treatments reduced the potash uptake by weeds. Treatment W_7 recorded minimum potash uptake by weeds (5.56 kg/ha) which is followed by W_3 (18.54 kg/ha), W_4 (21.76 kg/ha) and W_2 (95.61 kg/ha). The removal of potash was greatest under treatment W_8 (304.61 kg/ha).

4.2 EFFECT OF TREATMENTS ON GROWTH AND YIELD ATTRIBUTES OF PEAS

4.2.1 Germination (%) and plant stand

Data on germination (%) at 10 DAS and plant stand recorded at 20 DAS inoculation/uninoculation and weed management practices are presented in Table 4.8.

4.2.1.1 Effect of *Rhizobium* inoculation

Germination per cent recorded at 10 days after sowing and plant stand recorded at 10 DAS were significantly not affected due to

Rhizobium inoculation. The treatments R_1 and R_2 recorded the germination per cent of 84.28 and 83.94 respectively and the plant stand of 505.62 and 503.62 at 20 DAS, respectively.

4.2.1.2 Effect of weed management practices

Data presented in Table 4.8 revealed that the differences in germination per cent and plant stand were found non significant.

Germination per cent recorded at 10 DAS was not significantly influenced by various weed management practices. The highest germination per cent was recorded under treatment W_2 (86.12) and it was statistically at par with all the treatments. Significantly the lowest germination per cent was noted under treatment W_3 (82.12).

The highest plant stand at 20 DAS was recorded under treatment W_2 (516.75) and it was statistically at par with all the treatments. Significantly the lowest plant stand was noted under treatment W_3 (492.75).

4.2.1.3 Interaction effect

Interaction effect of R x W on germination per cent at 10 DAS and plant stand at 20 DAS were found non-significant (Table 4.8).

Table 4.8 : Germination per cent 10 DAS and plant stand 20 DAS as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Germination (%) 10 DAS	Plant stand 20 DAS
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	84.28	505.62
R_2 = Without *Rhizobium* inoculation	83.94	503.62
S.Em. $\pm$	1.055	6.323
CD (0.05)	NS	NS
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	84.38	506.25
W_2 : Fluchloralin 0.90 kg/ha	86.12	516.75
W_3 : Pendimethalin 0.50 kg/ha	82.12	492.75
W_4 : Pendimethalin 0.75 kg/ha	83.25	499.25
W_5 : Alachlor 0.60 kg/ha	85.37	512.25
W_6 : Alachlor 1.20 kg/ha	83.50	501.00
W_7 : HW 15,30 DAS	83.12	498.75
W_8 : Weedy check	85.00	510.00
S.Em. $\pm$	2.109	12.646
CD (0.05)	NS	NS
R x W interaction	NS	NS
CV %	7.09	7.09

4.2.2 Plant height

Data on plant height (cm) recorded at 30 DAS and at harvest as influenced by *Rhizobium* inoculation and weed management practices and their interaction effect are presented in Table 4.9 and graphically depicted in Fig. 4.3.

4.2.2.1 Effect of *Rhizobium* inoculation

Plant height recorded at 30 DAS and at harvest were significantly not affected due to *Rhizobium* inoculation. The treatment R_1 and R_2 recorded the plant height at 30 DAS of 33.36 and 32.88 respectively, while plant height at harvest were 38.73 and 38.61 respectively for R_1 and R_2 treatment.

4.2.2.2 Effect of weed management practices

Data presented in Table 4.9 revealed that plant height recorded at 30 DAS and at harvest was markedly influenced due to various weed management practices. Treatment W_3 recorded significantly higher plant height of 36.75 cm being at par with treatments W_4 (36.52 cm) and W_7 (36.61 cm). However, at harvest, treatment W_7 recorded significantly higher plant height of 41.41 cm being at par with W_3 (40.74 cm) and W_4 (40.78 cm). Treatments W_3, W_4 and W_7 tended to significantly increased the plant height at all the growth stages as compared to treatment W_8. An increase in plant height under treatments W_3, W_4 and W_7 was 30.50, 29.69

and 30.00%, 17.98, 18.10 and 19.92% at 30 DAS and at harvest, respectively.

Table 4.9: Plant height recorded at 30 DAS and at harvest as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Plant height (cm)	
	30 DAS	At harvest
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	33.36	38.73
R_2 = Without *Rhizobium* inoculation	32.88	38.61
S.Em. ±	0.313	0.243
CD (0.05)	NS	NS
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	33.14	39.22
W_2 : Fluchloralin 0.90 kg/ha	32.12	38.95
W_3 : Pendimethalin 0.50 kg/ha	36.75	40.74
W_4 : Pendimethalin 0.75 kg/ha	36.52	40.78
W_5 : Alachlor 0.60 kg/ha	30.01	36.46
W_6 : Alachlor 1.20 kg/ha	31.65	37.26
W_7 : HW 15,30 DAS	36.61	41.41
W_8 : Weedy check	28.16	34.53
S.Em. ±	0.625	0.487
CD (0.05)	1.77	1.38
R x W interaction	NS	NS
CV %	5.34	3.56

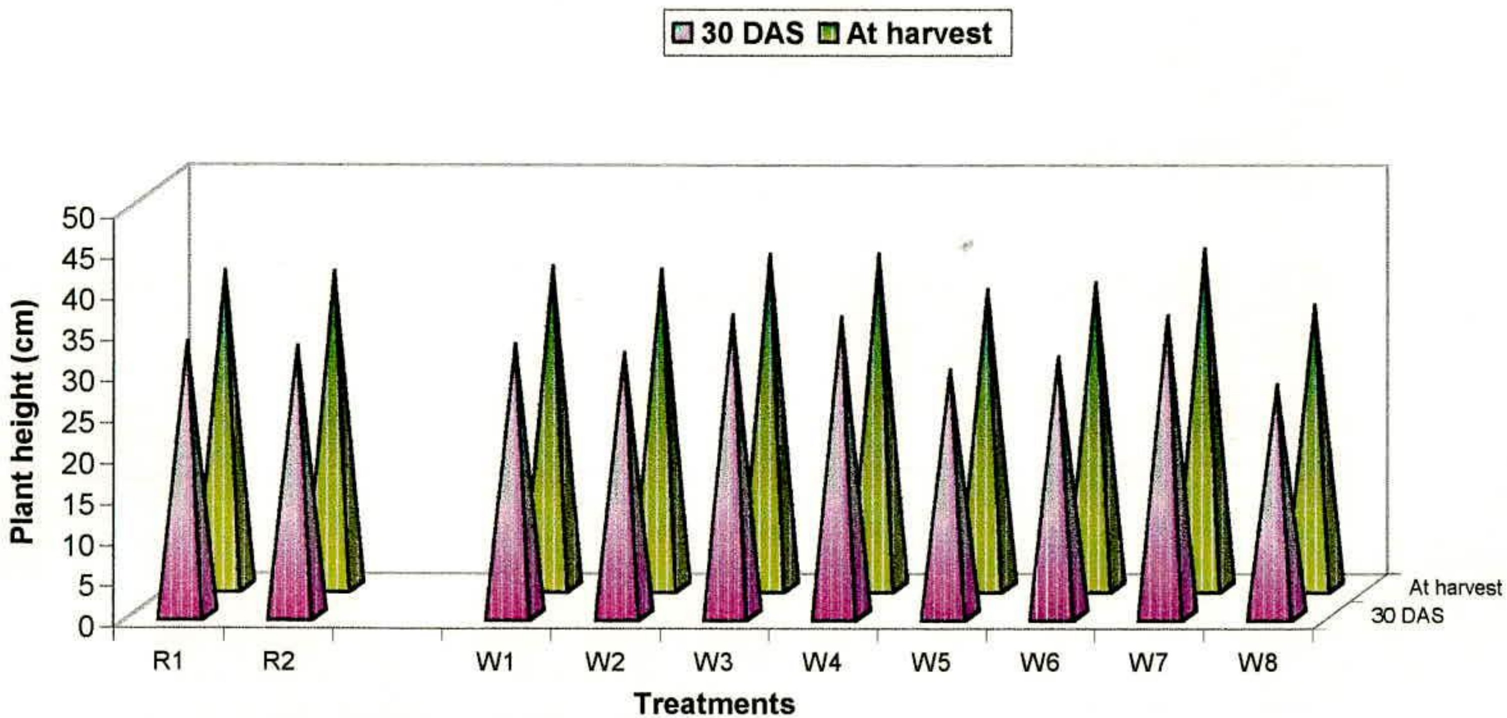


Fig. 4.3 : Plant height (cm) at 30 DAS and at harvest as influenced by different weed management practices and *Rhizobium* inoculation treatmetns

4.2.2.3 Interaction effect

Interaction effect of R x W on plant height at 30 DAS and at harvest were found to be non-significant (Table 4.9).

4.2.3 Number of root nodules/plant

Data on the effect of different weed control treatments and *Rhizobium* inoculation on number of root nodules per plant recorded at harvest are presented in Table 4.10 and graphically depicted in Fig. 4.4.

4.2.3.1 Effect of *Rhizobium* inoculation

A perusal of data given in Table 4.10 indicated that number of nodules per plant were significantly influenced by *Rhizobium* inoculation. Increasing trend in number of *Rhizobium* root nodules was noticed when the seeds are inoculated with *Rhizobium* inoculation as compare to those which are uninoculated. The number of nodules per plant were 5.29 and 4.29 with R_1 and R_2 respectively.

4.2.3.2 Effect of weed management practices

Number of nodules per plant were found non-significant due to different weed management practices.

4.2.3.3 Interaction effect

Interaction effect was not significant (Table 4.10).

Table 4.10: Number of nodules and dry weight of nodules (mg) per plant as influenced by weed management practices and *Rhizobium* inoculation treatments

Treatment	No. of Nodules/ plant	Dry wt. of nodules (mg)
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	5.29	10.85
R_2 = Without *Rhizobium* inoculation	4.83	9.93
S.Em. ±	0.119	0.172
CD (0.05)	0.336	0.487
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	4.96	10.96
W_2 : Fluchloralin 0.90 kg/ha	4.54	10.88
W_3 : Pendimethalin 0.50 kg/ha	5.08	9.71
W_4 : Pendimethalin 0.75 kg/ha	5.07	10.48
W_5 : Alachlor 0.60 kg/ha	5.27	10.48
W_6 : Alachlor 1.20 kg/ha	5.16	10.33
W_7 : HW 15,30 DAS	5.41	10.10
W_8 : Weedy check	5.00	10.18
S.Em. ±	0.237	0.344
CD (0.05)	NS	NS
R x W interaction	NS	NS
CV %	13.26	9.37

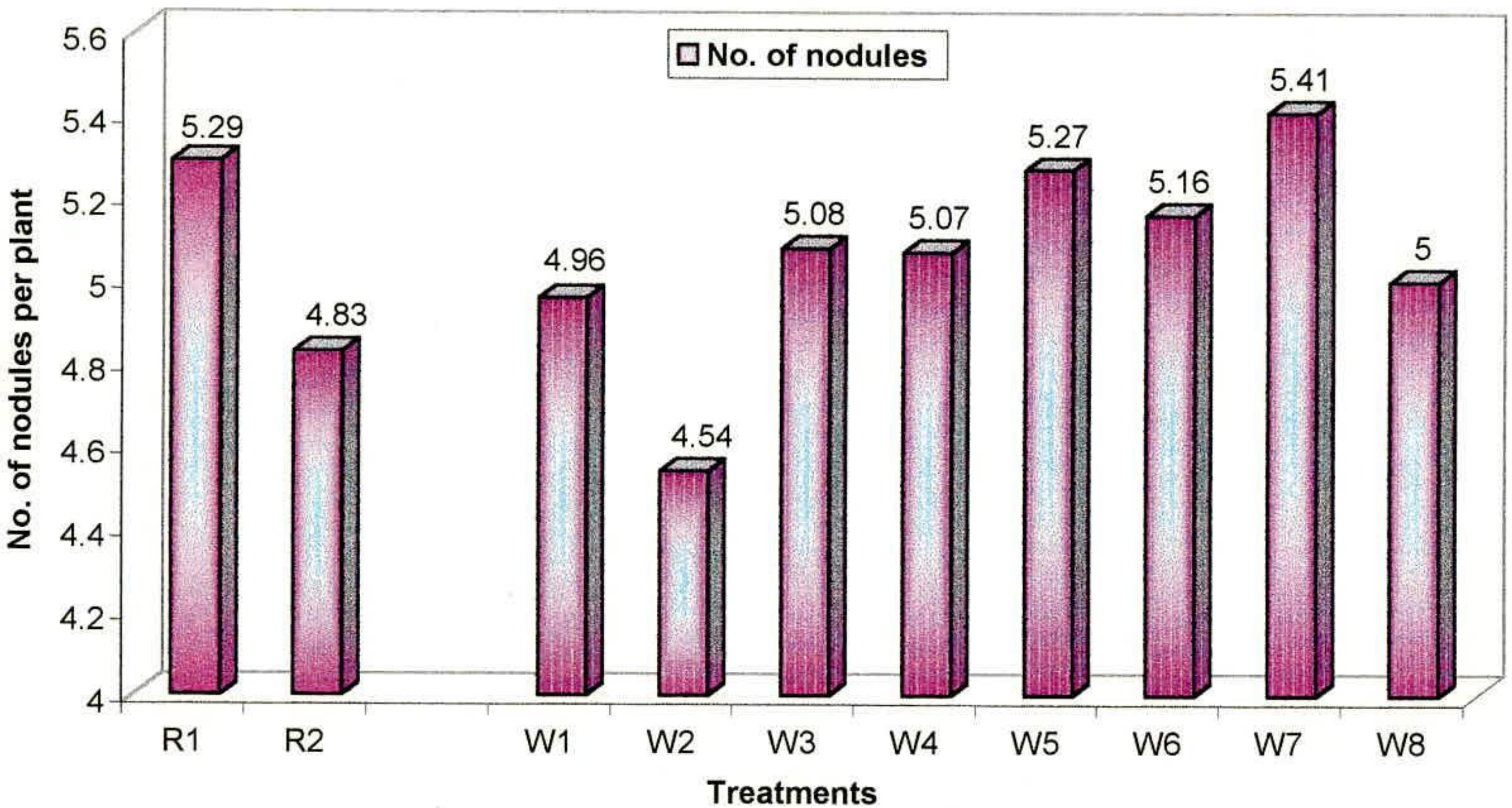


Fig. 4.4: Number of nodules per plant as influenced by weed managment practices and *Rhizobium* inoculation treatments

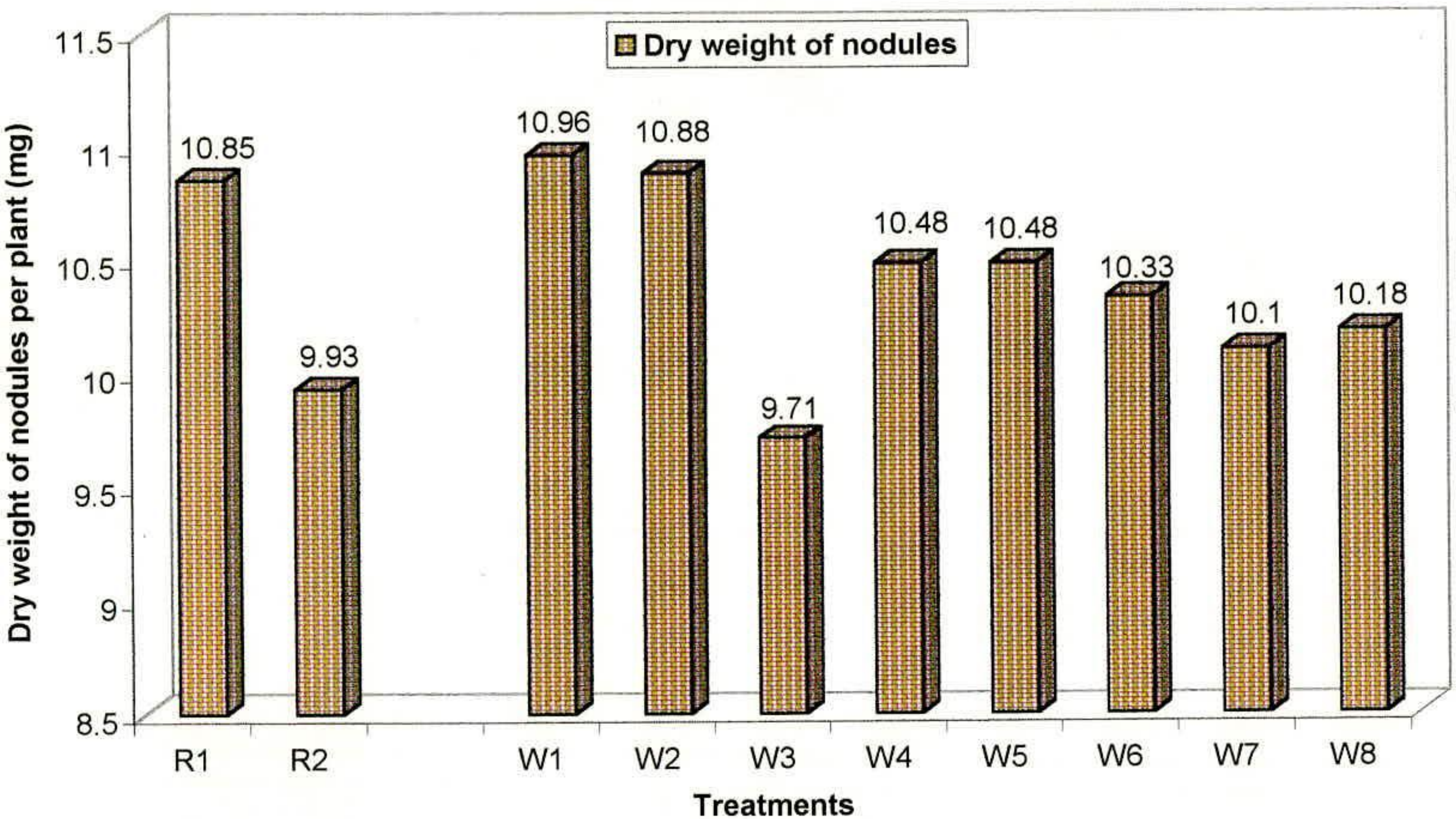


Fig. 4.5 : Dry weight of nodules per plant (mg) as influenced by weed managment practices and *Rhizobium* inoculation treatments

4.2.4 Dry weight of nodules per plant (mg)

Data regarding the dry weight of *Rhizobium* nodules per plant as affected by different weed management practices and *Rhizobium* inoculation treatments are presented in Table 4.10 and graphically illustrated in Fig 4.5.

4.2.4.1 Effect of *Rhizobium* inoculation

A perusal of data given in Table 4.10 indicated that dry weight of nodules per plant (mg) were significantly influenced by *Rhizobium* inoculation. Increasing trend in dry weight of *Rhizobium* root nodules was noticed when the seeds are inoculated with *Rhizobium* as compared to those which are un-inoculated. The dry weight of nodules per plant were 10.85 and 9.93 mg with R_1 and R_2, respectively.

4.2.4.2 Effect of weed management practices

Dry weight of nodules per plant were found non-significant due to different weed management practices.

4.2.4.3 Interaction effect

Interaction effect was non-significant (Table 4.10).

4.2.5 Number of pods per plant

Data pertaining to number of pods per plant as affected by various treatments of weed management practices and *Rhizobium* inoculation are presented in Table 4.11 and graphically depicted in Fig. 4.6.

Table 4.11: Number of pods per plant and number of seeds per pod as influenced by varying weed management practices and *Rhizobium* inoculation treatments

Treatment	No. of pods/plant	No. of seeds/pod
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	7.97	7.09
R_2 = Without *Rhizobium* inoculation	8.11	7.18
S.Em. ±	0.126	0.136
CD (0.05)	NS	NS
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	7.66	6.75
W_2 : Fluchloralin 0.75 kg/ha	7.29	7.16
W_3 : Pendimethalin 0.50 kg/ha	10.45	7.29
W_4 : Pendimethalin 0.75 kg/ha	10.16	7.29
W_5 : Alachlor 0.60 kg/ha	6.45	7.20
W_6 : Alachlor 1.20 kg/ha	6.21	7.12
W_7 : HW 15,30 DAS	10.41	7.16
W_8 : Weedy check	5.70	7.12
S.Em. ±	0.252	0.272
CD (0.05)	0.712	NS
R x W interaction	S	NS
CV %	8.85	10.78

4.2.5.1 Effect of *Rhizobium* inoculation

The effect of *Rhizobium* inoculation on number of pods per plant was found to be non-significant.

4.2.5.2 Effect of weed management practices

It was observed from the results presented in Table 4.11 that number of pods per plant were significantly influenced by different weed management practices. The maximum number of pods per plant (10.45) was recorded under W_3 treatment which was at par with treatments W_4 (10.16) and W_7 (10.41). The minimum number of pods per plant was recorded under treatment W_8 (5.70).

4.2.5.3 Interaction effect

Comparison of the treatments indicated that in case of *Rhizobium* inoculation, higher number of pods per plant was recorded in case of W_7 (10.83) followed by W_4 (10.49) and W_3 (10.16) and they were at par. Whereas, in case of no inoculation, W_3 (10.74) recorded maximum number of pods per plant being at par with W_7 (10.00) and W_4 (9.83) (Table 4.12).

4.2.6 Number of seeds per pod

Data pertaining to the effect of various treatments on number of seeds per pod recorded at harvest are presented in Table 4.11.

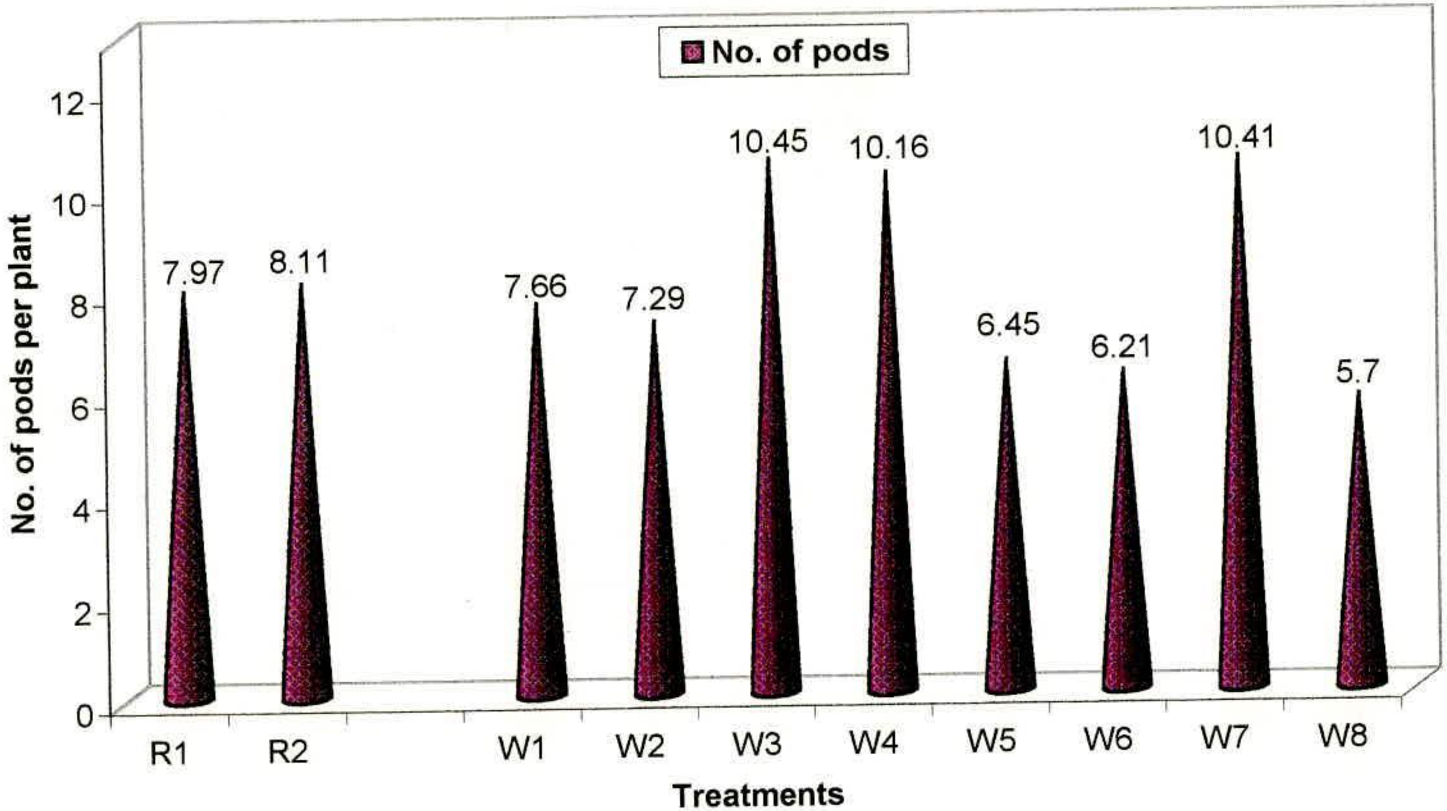


Fig. 4.6 : Number of pods per plant as influenced by weed mamagement practices and *Rhizobium* inoculation treatments

Table 4.12 : Number of pods/plant as influenced by R x W interaction

Weed management practices (W)	*Rhizobium* inoculation (R)	
	R_1	R_2
W_1	6.50	8.83
W_2	6.66	7.91
W_3	10.16	10.74
W_4	10.49	9.83
W_5	6.74	6.16
W_6	6.25	6.16
W_7	10.83	10.00
W_8	6.16	5.25
S.Em.	0.356	-
C.D.	1.01	-

4.2.6.1 Effect of *Rhizobium* inoculation and weed management practices

A perusal of data given in Table 4.11 revealed that *Rhizobium* inoculation and weed management treatments did not show significant influence on number of seeds per pod. This indicates uniform number of seeds per pod under all the treatments.

4.2.6.2 Interaction effect

Interaction effect of *Rhizobium* inoculation and weed management practices was non-significant (Table 4.11).

4.2.7 Weed index (WI)

Data pertaining to weed index (%) are presented in Table 4.13 indicated that amongst *Rhizobium* inoculation treatments the weed index was found to be (49.13% and (50.31%) for treatments R_1 and R_2, respectively.

Among all the weed management treatments, treatment W_4 (Pendimethalin 0.75 kg/ha) recorded lower weed index (9.63%) closely followed by treatments W_3 (13.26%) and W_2 (15.37 %). The maximum weed index was noted under W_8 weedy check (62.85%) followed by treatments W_5 (48.23%) and W_6 (33.86%). This indicated that these treatments were very effective in minimizing the yield losses due to weeds in peas.

4.2.8 Harvest index (HI)

Data pertaining to harvest index (%) are presented in Table 4.13 indicated that *Rhizobium* inoculation treatments were not found to be significant having (73.08 % and 70.66 %) for R_1 and R_2 respectively.

Table 4.13: Weed index and harvest index as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Weed index (%)	Harvest index (%)
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	26.97	70.66
R_2 = Without *Rhizobium* inoculation	25.23	73.08
S.Em. ±	-	2.522
CD (0.05)	-	NS
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	25.62	71.45
W_2 : Fluchloralin 0.90 kg/ha	15.37	65.44
W_3 : Pendimethalin 0.50 kg/ha	13.26	75.97
W_4 : Pendimethalin 0.75 kg/ha	9.63	76.40
W_5 : Alachlor 0.60 kg/ha	48.23	72.79
W_6 : Alachlor 1.20 kg/ha	33.86	76.31
W_7 : HW 15,30 DAS	-	79.79
W_8 : Weedy check	62.85	72.47
S.Em. ±	-	2.522
CD (0.05)	-	NS
R x W interaction	-	NS
CV %	-	19.85

Plate V : Alachlor @ 0.6 kg/ha was not effective for controlling weeds

Plate VI : The most of the weeds are removed in Hand weeding at 15 and 30 DAS

The effect of weed management practices were also found to be non-significant. The highest weed index was recorded under treatment W_7 (79.79 %) being followed by treatments W_4 (76.40 %) and W_6 (76.31 %).

The interaction effect was absent.

4.3 EFFECT OF TREATMENTS ON YIELD AND QUALITY

4.3.1 Pod and straw yields

The results on pod and straw yields as influenced by different weed management practices and *Rhizobium* inoculation are presented in Table 4.14 and graphically depicted in Figs. 4.7 and 4.8, respectively.

4.3.1.1 Effect of weed management practices

It was observed from the results furnished in Table 4.14 that yield was significantly influenced due to various weed management practices. The treatment W_7 ranked first by producing maximum pod yield of 8547 kg/ha, which was at par with treatments W_4, W_3 and W_2 having pod yield of 7724, 7414 and 7233 kg/ha respectively. Treatment W_8 lagged behind all the treatments by recording significantly the lowest pod yield of 3175 kg/ha. The per cent increase in pod yield under treatments W_7, W_4, W_3 and W_2 over treatment W_8 was 169.19, 143.27, 133.50 and 127.82, respectively.

Table 4.14: Pod and straw yield (kg/ha) of peas as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Pod yield (kg/ha)	Straw yield (kg/ha)
***Rhizobium* inoculation (R)**		
R_1 = With *Rhizobium* inoculation	6242	1631
R_2 = Without *Rhizobium* inoculation	6390	1507
S.Em. ±	250	65
CD (0.05)	NS	NS
Weed management practices (W)		
W_1 : Fluchloralin 0.45 kg/ha	6357	1584
W_2 : Fluchloralin 0.90 kg/ha	7233	1751
W_3 : Pendimethalin 0.50 kg/ha	7414	1861
W_4 : Pendimethalin 0.75 kg/ha	7724	1806
W_5 : Alachlor 0.60 kg/ha	4425	1223
W_6 : Alachlor 1.20 kg/ha	5653	1471
W_7 : HW 15,30 DAS	8547	1875
W_8 : Weedy check	3175	978
S.Em. ±	499.24	129.42
CD (0.05)	1412	366
R x W interaction	NS	NS
CV %	22.36	10.78

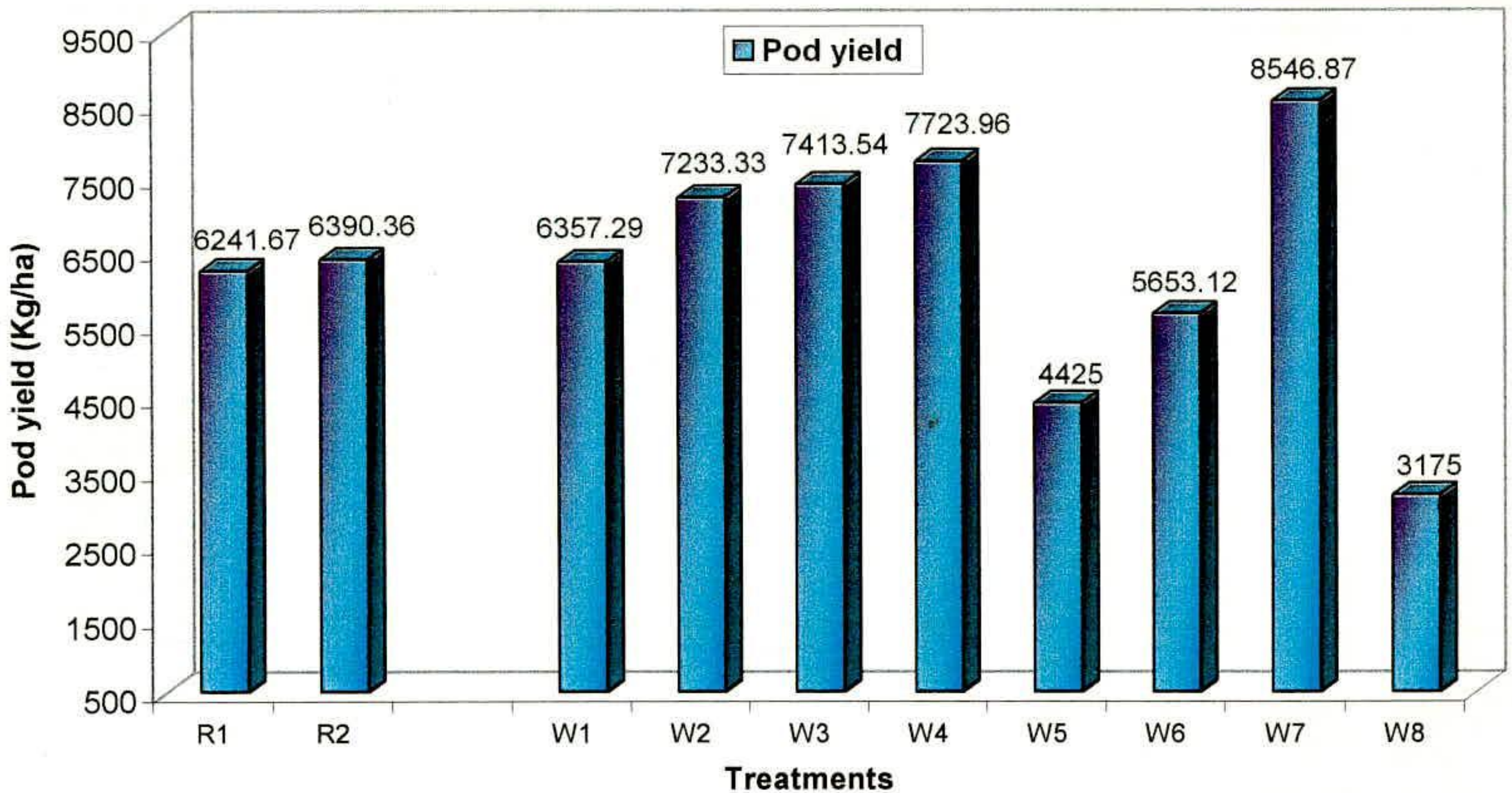


Fig. 4.7 : Total green pod yield (kg/ha) of peas as influenced by different weed management practices and *Rhizobium* inoculation treatmetns

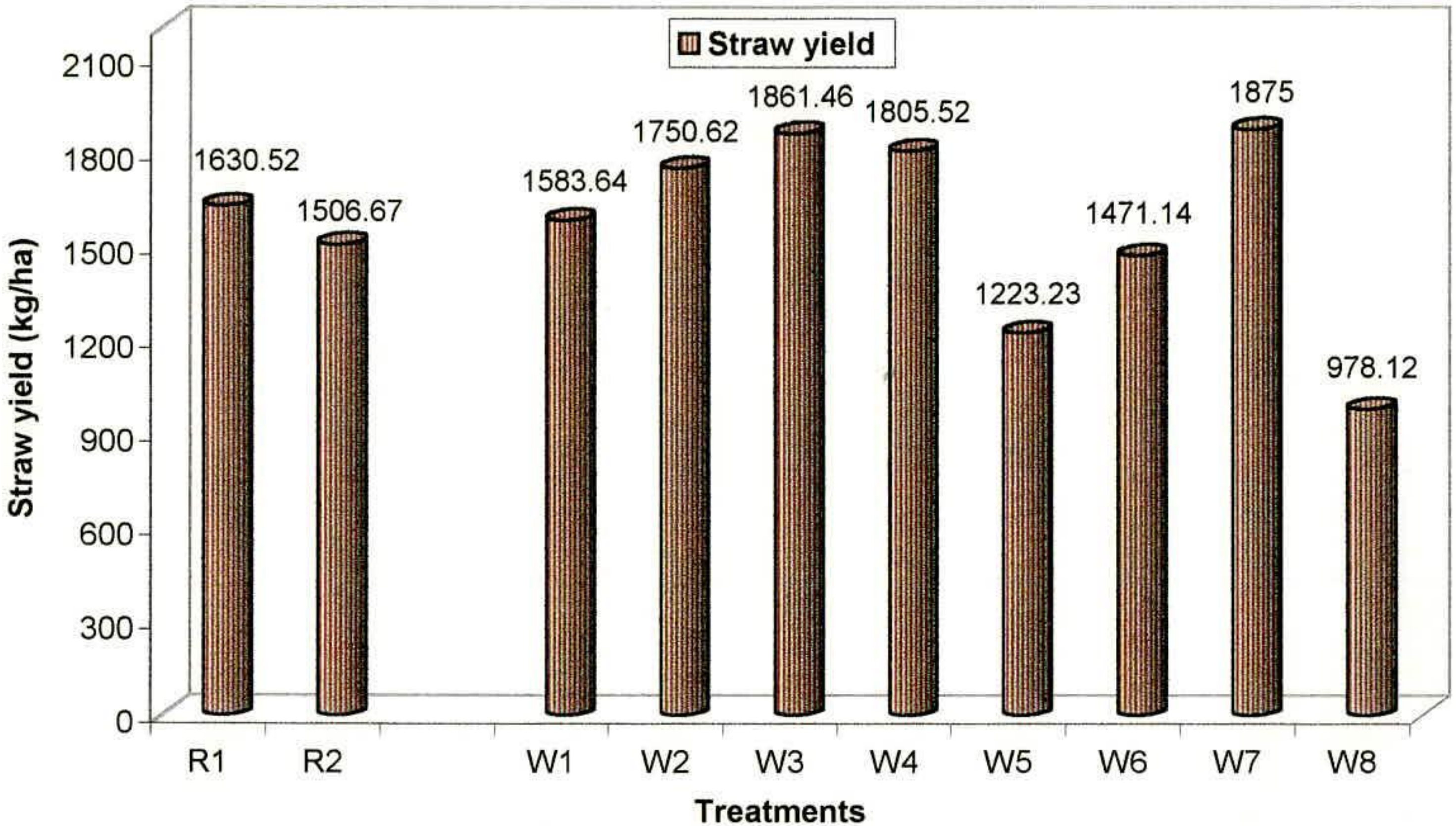


Fig. 4.8 : Total straw yield (kg/ha) of peas as influenced by different weed managment practices and *Rhizobium* inoculation treatmetns

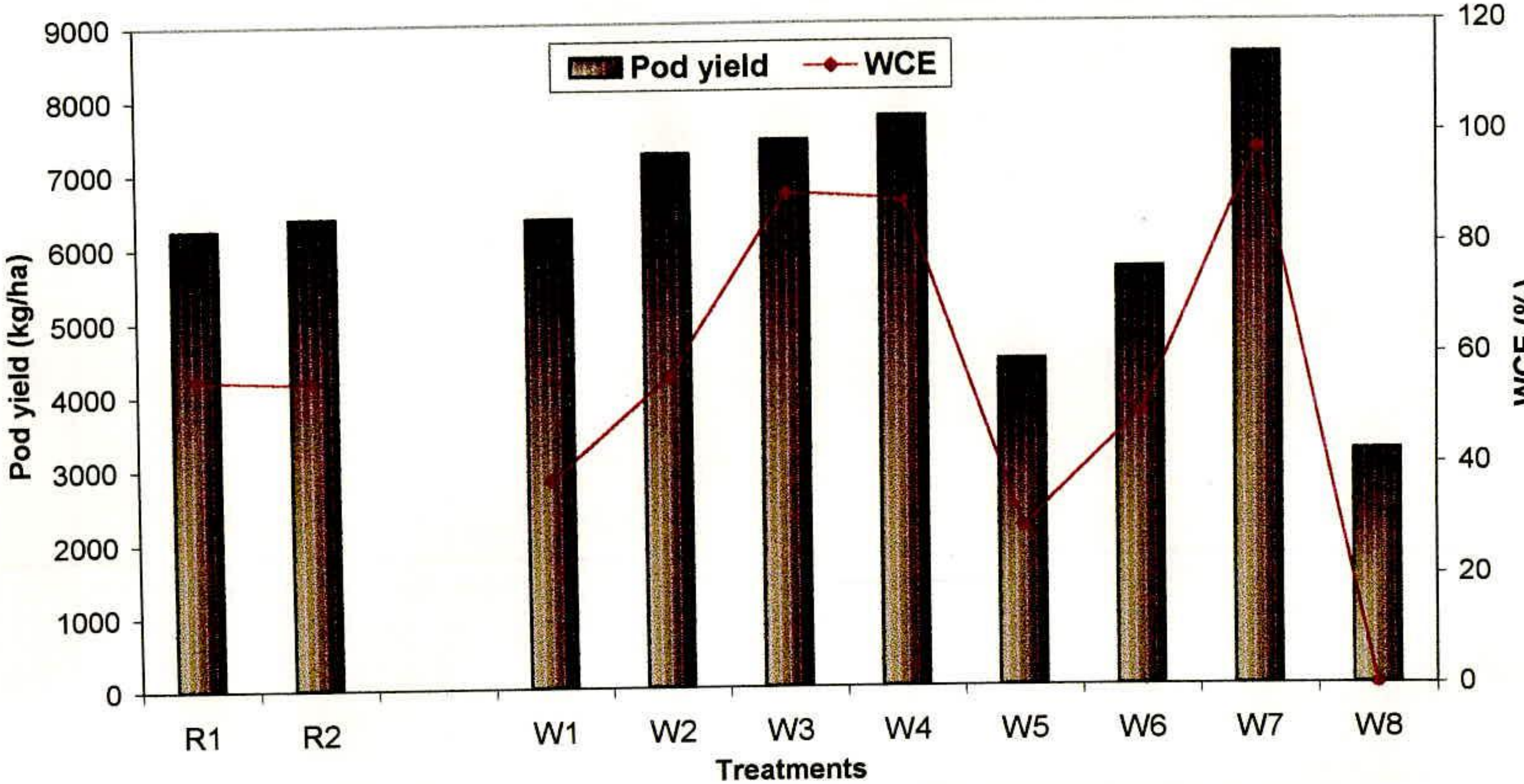


Fig. 4.9: Pod yield (kg/ha) and weed control efficiency (%) as influenced by different weed managment practices and *Rhizobium* inoculation treatments

The results presented in Table 4.14 revealed that straw yield was significantly influenced due to different weed management practices. Among different weed management treatments, W_7 registered maximum straw yield (1875.00 kg/ha) which was found to be at par with treatments W_3 (1861 kg/ha), W_4 (1806 kg/ha) W_2 (1751 kg/ha) and W_1 (1584 kg/ha). The treatment W_8 recorded the lowest straw yield of 978 kg/ha. The per cent increase in straw yield under treatments W_7, W_3, W_4, W_2 and W_1 over treatment W_8 was 91.69, 90.31, 84.59, 78.98 and 61.91%, respectively.

4.3.1.2 Effect of *Rhizobium* inoculation

The effect of *Rhizobium* inoculation on pod and straw yield of pea was found to be non-significant (Table 4.14).

4.3.1.3 Interaction effect

Interaction effects R x W for pod and straw yield were found non-significant (Table 4.14).

4.3.2 Protein content of seed

Data on protein content of seeds in different picking as influenced by different weed management practices and *Rhizobium* inoculation are presented in Table 4.15.

4.3.2.1 Effect of weed management practices

The differences in protein content of seeds in different picking were found to be significant (Table 4.15).

Table 4.15 : Protein content (%) of pea seeds as influenced by different weed management practices and *Rhizobium* inoculation treatments

Treatment	Protein (%) in different picking			
	1st	2nd	3rd	4th
***Rhizobium* inoculation (R)**				
R_1 = With *Rhizobium* inoculation	4.71	5.59	7.96	8.14
R_2 = Without *Rhizobium* inoculation	4.60	5.44	8.24	7.68
S.Em. ±	0.132	0.111	0.118	0.183
CD (0.05)	NS	NS	NS	NS
Weed management practices (W)				
W_1 : Fluchloralin 0.45 kg/ha	4.73	4.99	7.69	8.09
W_2 : Fluchloralin 0.90 kg/ha	4.83	5.07	7.75	6.97
W_3 : Pendimethalin 0.50 kg/ha	4.94	5.98	9.18	8.52
W_4 : Pendimethalin 0.75 kg/ha	4.89	6.71	9.06	8.28
W_5 : Alachlor 0.60 kg/ha	4.82	5.34	7.83	8.47
W_6 : Alachlor 1.20 kg/ha	4.71	5.24	8.01	7.00
W_7 : HW 15,30 DAS	4.88	6.37	9.04	9.08
W_8 : Weedy check	3.45	4.41	6.24	6.84
S.Em. ±	0.265	0.222	0.236	0.366
CD (0.05)	0.749	0.629	0.667	1.036
R x W interaction	NS	NS	NS	NS
CV %	16.09	11.40	8.23	13.11

During first picking, among all the treatments, treatment W_3 recorded the highest protein per cent of (4.94%) which was found to be at par with all the treatments W_4 (4.89 %), W_7 (4.88%), W_2 (4.83 %), W_5 (4.82 %), W_1 (4.73 %) and W_6 (4.71 %) except W_8 which recorded the lowest protein content of 3.45 %.

During second picking, among all the treatments, treatment W_4 recorded the highest protein per cent of 6.71 % which was at par with treatment W_7 (6.37 %). The lowest protein content was recorded under treatment W_8 (4.41%).

During third picking , among all the treatments, treatment W_3 recorded the highest protein content of 9.18 % which was at par with treatments W_4 (9.06%) and W_7 (9.04%). The lowest protein content was recorded under treatment W_8 (6.24 %).

During fourth picking, among all the treatments, treatment W_7 recorded the highest protein content of 9.08% which was at par with treatments W_3 (8.52%), W_4 (8.28 %), W_5 and W_1 (8.09%). The lowest protein content of seeds was recorded under treatment W_8 (6.84 %).

4.3.2.2 Effect of *Rhizobium* inoculation

The data on protein content (%) in different picking showed that *Rhizobium* inoculation treatments have not any significant effect (Table 4.15).

4.3.2.3 Interaction effect

The interaction effect on protein content by seed was absent (Table 4.15).

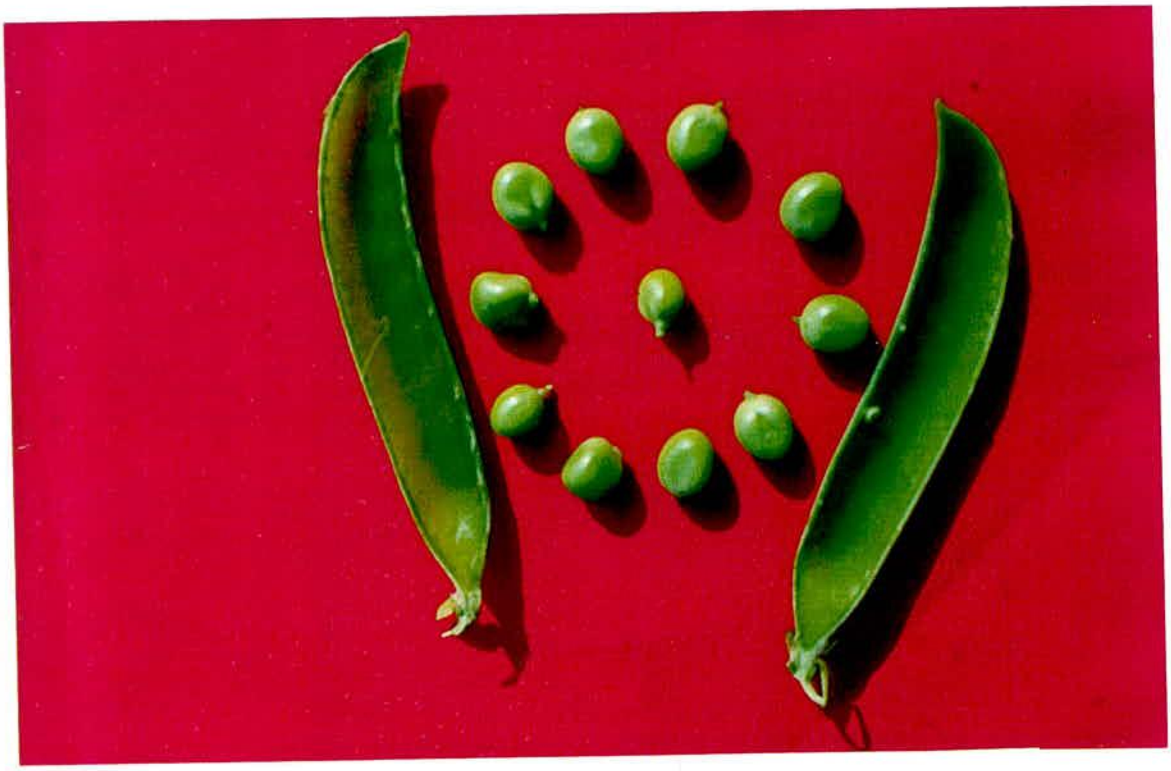


Plate VII : Sweet seeds in a single pod of pea

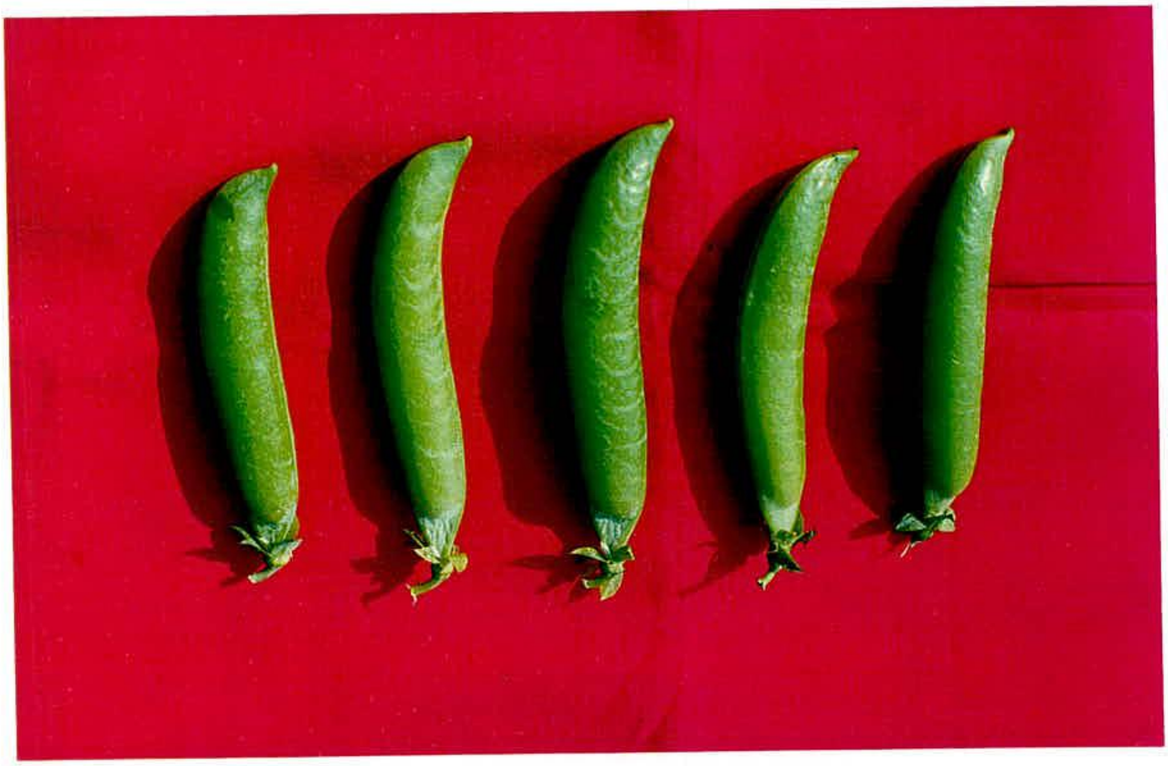


Plate VIII : Long and healthy pods of pea

4.4 ECONOMICS OF DIFFERENT WEED CONTROL TREATMENTS

In order to evaluate the effectiveness of treatments, economics was worked out and presented in Table 4.16 and also graphically depicted in Fig. 4.10.

Various weed control treatments exhibited interesting trend with regards to economics aspect. All the weed control treatments were definitely better (Rs. 4441 to Rs. 53856) than weedy check.

The most advantageous treatment was R_1W_7 (Hand Weeding at 20 and 40 DAS) resulting in the highest pod yield of 8721 kg/ha with the maximum net profit of Rs. 53,856/ha. The other greater profitable treatments were R_2W_7 (Hand Weeding at 20 and 40 DAS without *Rhizobium* inoculation), R_1W_3, R_1W_4, R_2W_2 which recorded net returns of Rs. 50328, Rs. 50090, Rs. 45969 and Rs. 44233/ha, respectively.

With regards to cost benefit ratio (CBR), treatment combination R_1W_7 had given the highest returns per rupee (2.59) followed by R_1W_3 (2.49), R_2W_7 (2.49), R_1W_4 (2.35). The lowest CBR (0.89) was recorded under the treatment combination R_1W_8 (weedy check with *Rhizobium* inoculation).

Table 4.16 : Gross realization, total cost of cultivation, net realization and CBR as influenced by different treatment combinations

Sr. No.	Treatment combination	Pod yield (kg/ha)	Straw yield (kg/ha)	Gross realization (Rs.)	Total cost of cultivation (Rs./ha)	Net realization (Rs./ha)	CBR
1.	R_1W_1	6752.08	1722.92	67951.53	33305	34646	2.04
2.	R_1W_2	6695.83	1861.67	67423.72	33885	33539	1.99
3.	R_1W_3	8316.67	2085.42	83688.05	33589	50099	2.49
4.	R_1W_4	7952.08	1777.71	79963.80	33995	45969	2.35
5.	R_1W_5	3727.08	1166.67	37562.47	33121	4441	1.13
6.	R_1W_6	4891.67	1415.21	49270.50	33517	15753	1.47

Price : Pods : Rs. 10.00/kg
Straws: Rs. 0.25/kg
Basalin 45 EC (Fluchloralin) Rs. 580
Stomp 30 EC (Pendimethalin) Rs. 540
Lasso 50 EC (Alachlor) Rs. 330

Spraying cost of herbicide : Rs. 80/ha
Labour charge : Rs. 40/day
Total cost of cultivation other than weed control Rs. 32645.00

Sr. No.	Treatment combination	Pod yield (kg/ha)	Straw yield (kg/ha)	Gross realization (Rs.)	Total cost of cultivation (Rs./ha)	Net realization (Rs./ha)	CBR
7.	R_1W_7	8720.83	1972.92	87701.53	33845	53856	2.59
8.	R_1W_8	2877.08	1041.67	29031.22	32645	-3614	0.89
9.	R_2W_1	5962.50	1444.37	59986.00	33305	26681	1.80
10.	R_2W_2	7770.83	1639.58	78118.20	33885	44233	2.30
11.	R_2W_3	6510.42	1637.50	65513.57	33589	31925	1.95
12.	R_2W_4	7495.83	1833.33	75416.63	33995	41442	2.22
13.	R_2W_5	5122.92	1279.79	51549.20	33121	18428	1.56
14.	R_2W_6	6414.58	1527.10	64527.60	33517	31011	1.92
15.	R_2W_7	8372.92	1777.10	84173.47	33845	50328	2.49
16.	R_2W_8	3472.92	914.58	34957.84	32645	2313	1.07

Table 4.17 : Economics as influenced by *Rhizobium* inoculation and weed management practices

Treatment	Pod yield (kg/ha)	Straw yield (kg/ha)	Gross realization (Rs.)	Additional return over control (Rs./ha)	Additional cost over control (Rs./ha)	Total cost of cultivation (Rs./ha)	Net realization	CBR
***Rhizobium* inoculation (R)**								
R_1 = With *Rhizobium* inoculation	6242	1631	62,828	30,100	20	32,665	30,163	1.92
R_2 = Without *Rhizobium* inoculation	6390	1507	64,277	31,549	0	32,645	31,632	1.96
Weed management practices (W)								
W_1 : Fluchloralin 0.45 kg/ha	6357	1584	65,154	32,426	660	33,305	31,849	1.95
W_2 : Fluchloralin 0.90 kg/ha	7233	1751	74,081	41,353	1240	33,885	40,196	2.18
W_3 : Pendimethalin 0.50 kg/ha	7414	1861	76,001	43,273	406	33,589	41,412	2.26
W_4 : Pendimethalin 0.75 kg/ha	7724	1806	79,046	46,318	1350	33,995	45,051	2.32
W_5 : Alachlor 0.60 kg/ha	4425	1223	45,473	12,745	476	33,121	12,352	1.37
W_6 : Alachlor 1.20 kg/ha	5653	1471	58,001	25,273	872	33,517	24,484	1.73
W_7 : HW 15,30 DAS	8547	1875	87,345	54,167	800	33,445	53,900	2.61
W_8 : Weedy check	3175	978	32,728	-	-	32,645	83	1.00

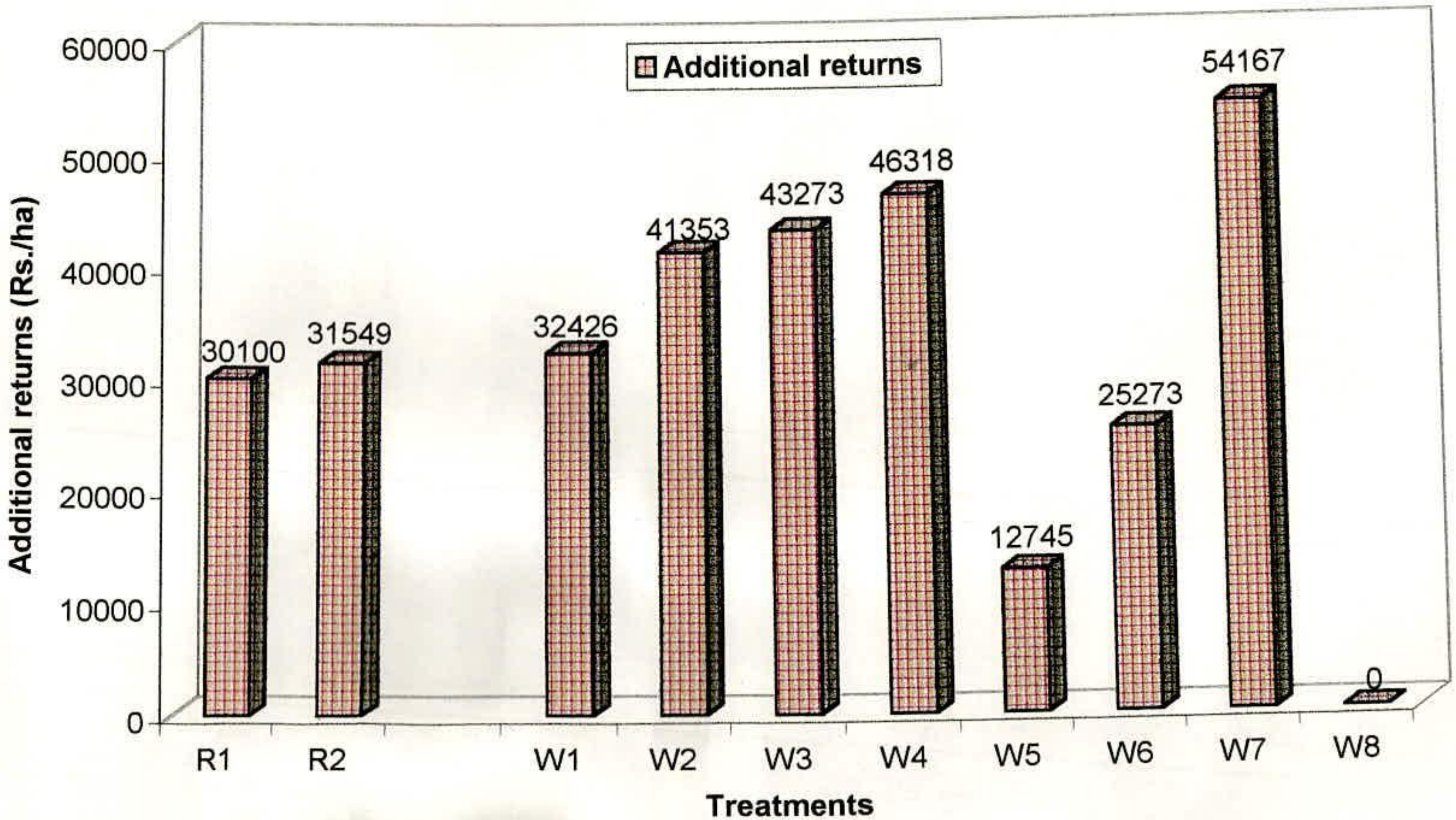


Fig. 4.10: Additonal returns over control (Economics) as influenced by weed managment practices and *Rhizobium* inoculation treatments

Table 4.18 : Correlation between yield attributes and weed parameters of peas

Sr. No.	Character	Number of seeds/ pod	Number of pods/ plant	Pod yield (kg/ha)	Straw yield (kg/ha)	Weeds count at			Dry weight of weed (kg/ha)	N content by weed (%)	P_2O_5 content by weed (%)	K_2O content by weed (%)
						20	40	Harvest				
1.	Number of seeds/pod	1.000										
2.	Number of pods/plant	0.514*	1.000									
3.	Pod yield (kg/ha)	0.334	0.70**	1.000								
4.	Straw yield (kg/ha)	0.210	0.354	0.586*	1.000							
5.	Weeds count at 20 DAS	-0.429	-0.924**	-0.869**	-0.450	1.000						
6.	Weeds count at 40 DAS	-0.447	-0.854**	-0.893**	-0.497*	0.887**	1.000					
7.	Weeds count at harvest	-0.442	-0.837**	-0.866**	-0.463	0.871**	0.981**	1.000				
8.	Dry weight of weeds (kg/ha)	-0.370	-0.549*	-0.568*	-0.440	0.658**	0.645**	0.653**	1.000			
9.	N content of weed (%)	-0.683**	-0.734**	-0.775**	-0.408	0.791**	0.833**	0.859**	0.775**	1.000		
10.	P_2O_5 content by weed (%)	-0.373	-0.725**	-0.842**	0.425	0.760**	0.87**	0.862**	0.688**	0.913**	1.000	
11.	K_2O content by weed (%)	-0.526*	-0.682**	-0.855**	-0.586*	0.730**	0.797**	0.797**	0.701**	0.789**	0.831 **	1.000

* Significant at 5% 0.496

** Significant at 1% 0.623

4.5 CORRELATION STUDIES

Data pertaining to correlation among weed parameters, pod yield and yield attributes are presented in Table 4.18. The results revealed that all weed parameters were negatively correlated with pod yield and yield attributes. However, weed parameters *viz.*, weeds count at 20 DAS, 40 DAS at harvest and dry weight of weeds at harvest were negatively and significantly correlated with pod yield. A significant and negative correlation was also noticed with content of nitrogen, phosphorus and potassium by weeds. Where as weed parameters *viz.*, weeds count at 20 DAS, 40 DAS, at harvest and dry weight of weeds at harvest showed negative and non-significant correlation with number of seeds per pod.

DISCUSSION

V. DISCUSSION

In order to sustain the higher productivity of quality food grain, there is a need to refine the agronomic practices like weed management practices and *Rhizobium* inoculation. Because the *Rhizobium* root nodules have ability to fix the atmospheric nitrogen. Simultaneously weed management is also necessary, because weeds compete with crop at very initial stage and they adversely affect crop growth, yield and quality of produces, so weeds should be removed at a critical period of crop weed competition by using herbicide or by manually.

Keeping above points in view, present investigation was carried out. In this chapter it is contemplated to discuss the variations obtained in the results of the study reported in preceding chapter. Moreover, it has been attempted to establish cause and effect relationship in light of available evidence and literature.

The results are discussed in the following heads :

5.1 EFFECT OF TREATMENTS ON WEEDS.

5.2 EFFECT OF TREATMENTS ON GROWTH AND YIELD ATTRIBUTES OF PEAS.

5.3 EFFECT OF TREATMENTS ON YIELD AND QUALITY.

5.4 ECONOMICS OF DIFFERENT TREATMENTS.

Among different factors responsible for influencing the yield and performance of crop as well as associated weeds, weather condition play a key role. Various weather parameters pertaining to the crop season were normal for *Rabi* peas (Table 3.1). The results obtained from the present experiment were not deviated by weather. The germination count was normal (Section 4.2, Table 4.8) and all the cultural requirements of the crops were met adequately in time. Hence, whatever variations observed in the results are attributed by the different treatments.

5.1 EFFECT OF DIFFERENT TREATMENTS ON WEED

The experimental site was infested by number of weed species. There were total twelve major weed species recorded in the experimental site of which seven were monocot weeds and five were dicot weeds (Section 4.1, Table 4.1).

Weeds count recorded at 20 DAS, 40 DAS, at harvest and dry weight of weeds at harvest are presented in Section 4.1, Table 4.2, all of them were significantly influenced by different weed management practices. In almost all weed management treatments considerable reduction in weed population was noted over weedy check. Hand weeding twice at 15, 30 DAS being at par with pendimethalin at both the rates (0.75 kg/ha) as well as (0.50 kg/ha). This might be due to the fact that at higher concentration of pendimethalin, germinating weed seeds might have been killed resulting into lower population of weed. Maximum weed population under weedy check was due to absence of management of weeds. However, application of alachlor at both the lower (0.60 kg/ha) and higher (1.20 kg/ha) doses were significantly inferior to hand weeding twice at 15 and 30 DAS. This could be attributed to failure of this chemical in controlling weeds. The similar result was obtained by Saimbhi *et al.* (1990). The highest reduction achieved in case of manual weeding was due to the fact that initially weeds were controlled by hand weeding at 15 DAS and whatever weeds emerged later on were effectively removed by hand weeding at 30 DAS.

Weed control efficiency worked out at harvest (Section 4.1, Table 4.4) showed that maximum weed control efficiency was achieved under hand weeding twice at 15 and 30 DAS (97.2%) followed by pendimethalin at lower dose (89.3 %) and at higher dose (88.00%). These results are in agreement with the results reported by Kundra and Gill (1990) as well as Gogoi *et al.* (1991).

Data on nutrients depletion by weeds indicated that the removal of nutrients (NPK) by weeds in weed control treatments was considerably lower than that of unweeded control (Section 4.1 and Table 4.7). The minimum nutrients loss was observed in case of hand weeding twice at 15 and 30 DAS. This was closely followed by pre-emergence application of pendimethalin at lower dose and higher dose. From the foregoing discussion, it can be concluded that chemical weeding is one of the valuable tools after mechanical methods in minimizing a considerable extent of nutrients drain caused by weed growth thereby leading to improvement in the nutrition of the crop and enhancement in crop yield. Similar results have been also reported by earlier workers Singh *et al.* (1974).

The effect of *Rhizobium* inoculation on weeds count at 20 DAS, 40 DAS and at harvest, dry weight of weeds at harvest and weed control efficiency were found to be non significant (Section 4.1, Tables 4.2 and 4.4). It showed that *Rhizobium* inoculation treatments have not any significant effect among themselves.

A perusal of data on nutrients (NPK) content by weeds at harvest are presented in Section 4.1 and Table 4.5 indicated that *Rhizobium* inoculation treatments have significant effect on nitrogen content by weed. This might be due to fixation of nitrogen by *Rhizobium* bacteria which add more nitrogen in soil resulting into more nitrogen content by weeds. Similar observations were made by Srivastava and Ahlawat (1995).

5.2 EFFECT OF DIFFERENT TREATMENTS ON GROWTH AND YIELD ATTRIBUTES OF PEAS

Differences among the treatments for germination percentage at 10 DAS and plant stand recorded at 20 DAS were not influenced due to different weed management practices (Section 4.2, Table 4.8), indicating the absence of detrimental effect of pre-emergence herbicides on the crop.

Plant height (Section 4.2, Table 4.9 and Fig. 4.3) and number of pods per plant were (Section 4.2, Table 4.4) significantly influenced by different weed management practices. Among all the treatments, hand weeding at 15, 30 DAS as well as pendimethalin at both the doses 0.5 kg/ha and 0.75 kg/ha improved plant height at 30 DAS and at harvest as well as number of pods per plant. This could be attributed to effective weed control measures which appreciably reduced the weed population and thereby, uptake of nutrients by weeds. It could also be observed from correlation studies (Section 4.2, Table 4.18) that number of pods per plant has very high negative correlation with the weed count and nutrient status of weeds. The similar findings were obtained by Rathi *et al.* (1986). Unweeded control treatment recorded the lowest values of number of pods per plant. This may be due to strong competition of weeds with crop for growth factors under this treatment.

The effect of different weed management practices, number and dry weight of nodules per plant (Section 4.2, Table 4.10) were not remarkable. These might be due to phytotoxic effect of herbicides in soil which may reduce the activity of micro organisms in soil.

Data presented in Section 4.2 and Table 4.13 showed that the lower weed index corresponded to pendimethalin at 0.75 kg/ha followed by pendimethalin at 0.50 kg/ha and fluchloralin at 0.45 kg/ha. This indicated that these treatments are very effective in minimizing the losses due to weeds in pea. This results is in agreement with that reported by Auskalnis (1997). The results further revealed that alachlor at lower dose as well as at higher dose gave higher weed index indicating that this chemical is not effective fore pea crop in controlling weeds. Weedy check showed the highest weed index as weeds caused greater reduction in yield components like number of branches per plant, number of pods per plant and nutrients uptake by crop which led to lower pod yield.

A perusal of data given in Section 4.2 and Table 4.8 revealed that *Rhizobium* inoculation treatments did not show significant influenced on germination per cent, plant stand, periodical plant height (Section 4.2, Table 4.9), number of pods per plant and number of seeds per pod (Section 4.2, Table 4.13). It indicates that whether the seeds are inoculated with *Rhizobium* or absence of inoculum did not show any effect.

Data on number of nodules as well as dry weight of nodules per plant (Section 4.2, Table 4.10) revealed that *Rhizobium* inoculation treatments have significant influence. Significantly higher number of nodules and dry weight of nodules per plant recorded when the seeds are inoculated with *Rhizobium*. Increase in nodules number and dry weight of nodules per plant were also affected due to application of 20 kg N/ha as basal which could be attributed to increased availability of nitrogen at sowing probably had a boosting effect on root prolification and volume of root before the formation of nodules on root resulting into relative increase in total number of nodules and consequently the dry weight of nodules. These results are in conformity with finding of Jauhri *et al.* (1981), Prasad and Maurya (1992) and Ram and Sahoria (1979).

Data presented in Section 4.2 and Table 4.11 indicated that number of pods per plant varied significantly due to interaction effect of *Rhizobium* inoculation and weed management practices. Comparison of the treatments indicated that in case of *Rhizobium* inoculation, higher number of pods per plant was recorded in case of hand weeding twice at 15 and 30 DAS followed by pendimethalin at higher dose as well as lower dose and they were at par. Whereas, in case of no inoculation, pendimethalin at lower dose recorded maximum number of pods per plant being at par with hand weeding twice and pendimethalin at higher dose. Correlation studies also indicated that all the weed parameters have negative and highly significant association with number of pods per plant (Section 4.5, Table 4.18).

5.2 EFFECT OF TREATMENTS ON YIELD AND QUALITY

Data pertaining to the effect of different weed management practices on pod and straw yield of pea are presented in Section 4.3, Table 4.14 and graphically depicted in Fig. 4.7. The significant variation in pod and straw yield was recorded due to different weed management practices. The highest pod and straw yield was recorded under hand weeding twice at 15 and 30 DAS being at par with pendimethalin at higher dose as well as at lower dose. This indicated that yield is a function of the growth characters and yield attributes. The combined effect of these component resulted in higher pod yield. The higher pod yield with these treatments was further attributed to lower weed density (Section 4.1, Table 4.2) and dry weight of weeds (Section 4.1, Table 4.4) with highest weed control efficiency. Similar conclusions were drawn by Mishra and Bhan (1997) and Ved *et al.* (2000). Correlation studies also indicated that weed parameters *viz.,* weeds count at 20 DAS, 40 DAS, at harvest and dry weight of weeds were negatively and significantly correlated with pod yield. Unweeded control recorded the lowest pod and straw yield. This was because of a strong competition of weeds with crop for growth factors.

Though, lowest pod yield was obtained with weedy check, it was not significantly differed from the yield obtained from plots treated with alachlor at 0.60 kg/ha. This might be due to failure of alachlor for controlling weeds which caused the acute crop weed competition resulted in lower number of branches and number of pods per plant.

Weed management practices significantly influenced the protein content in different pickings. Almost in all the pickings, the highest protein content was recorded under treatments pendimethalin at 0.5 kg/ha, hand weeding twice at 15 and 30 DAS and pendimethalin at 0.75 kg/ha and all these treatments were statistically at par among themselves (Section 4.3, Table 4.15). This was evidently due to effective weed control right from the early stages of the crop resulted into higher pod yield as well as higher protein content in case of these treatments. Weedy check recorded the lowest protein content during all the pickings. This might be due to lowest pod yield, straw yield, nutrient uptake by crop in case of this treatment resulted from strong crop weed competition. It was observed that there was a drastically increase in protein per cent as the picking increases. This might be due to fact that as the maturing of crop increases the value of protein per cent also increases. A close examination of data in Table 4.15 also indicated that the protein per cent was higher corresponding to lower doses of herbicides as compared to higher doses of herbicides.

The data presented in Section 4.3, Tables 4.14 and 4.15 indicated that the effect of *Rhizobium* inoculation and interaction effect of *Rhizobium* inoculation and weed management practices on yield and quality components were found to be non-significant. The absence of interaction effect indicated that both the *Rhizobium* inoculation and weed management practices have an independent effect on crop.

5.3 ECONOMICS OF DIFFERENT TREATMENTS

It is very necessary to work out economics of different treatments for valid comparison of agronomic practices and sound recommendation of the same. Sometimes the most effective treatment may proved poor when tested on the basis of economics.

The economics of different weed control treatments are outlined in Section 4.4, Table 4.17 and Fig. 4.10 indicated that maximum net profit of Rs. 53,856/ha was recorded with treatment combination R_1W_7 (*Rhizobium* inoculation + HW at 15 and 30 DAS) followed by Rs. 50,328/ha in R_2W_7 (hand weeding at 15 and 30 DAS without *Rhizobium* inoculation), Rs. 50,094/ha in R_1W_3 (*Rhizobium* inoculation+pendimethalin @ 0.50 kg/ha), Rs. 45,969/ha in R_1W_4 (*Rhizobium* inoculation + pendimethalin @ 0.75 kg/ha). Higher profit in case of these treatments was due to increase in yield. These findings are in accordance with the findings of Kumar and Kairon (1988) and Kundra *et al.* (1989).

The loss of Rs. 3614/ha was observed under treatment combination R_1W_8 (weedy check). This may be due to profuse growth of weeds decreased the yield.

With regards to cost benefit ratio, treatment combination R_1W_7 (*Rhizobium* inoculation + HW at 15, 30 DAS) had given highest CBR (2.59) followed by treatment combinations R_1W_3 (*Rhizobium* inoculation + pendimethalin @ 0.50 kg/ha) and R_2W_7 (HW at 15, 30 DAS without *Rhizobium* inoculation) having same CBR (2.49). Higher CBR in case of twice hand weedings was due to lower cost of weed control and higher pod yield of peas. Patro and Prusty (1994) and Kumar *et al.* (1994) achieved maximum CBR when weeding was carried out at 20 and 35 DAS.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A field experiment was conducted at college Agronomy Farm under AICRP on Weed Control, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand during *Rabi* season of 2001-2002. The soil was loamy sand in texture, low in nitrogen, medium in phosphorus and high in potassium. The study was under taken with a view to study **"Effect of weed management practices and *Rhizobium* inoculation on growth and yield of peas (*Pisum sativum* L.)"**. Eight weed management treatments comprising three pre-emergence herbicides each at two levels *viz.*, fluchloralin (0.45 and 0.90 kg/ha), pendimethalin (0.5 and 0.75 kg/ha) and alachlor (0.60 and 1.20 kg/ha)and manual weeding at 15, 30 DAS and untreated check in combination with *Rhizobium* inoculation and without *Rhizobium* inoculation under factorial randomized complete block design with four replications. Pre-emergence application of herbicides was made the next day of sowing with the help of knapsack sprayer fitted with a flatfan nozzle using 500 litre of water /ha of spray solution. To evaluate the treatment effects, weed intensity was recorded periodically with quadrant 0.25 m^2 at two randomly selected points each net plot and also dry weight of total weeds were recorded periodically.

The salient features of findings are summarized as under :

1. All the herbicides were most effective against monocot and dicot weeds, but failed to control sedges.

2. Pendimethalin and hand weeding were almost equally effective in reducing weed flora and dry weight of weeds. Where as alachlor was not effective to reduce the weed flora. However, manual weeding twice proved highly beneficial in exterminating the weed flora. Weed control treatments reduced the dry weed biomass significantly to 136.87 - 3465.83 kg/ha as against 4881.56 kg/ha in weedy check. The higher weed control efficiency was noticed in case of hand weeding at 15, 30 DAS (97.2%) followed by pendimethalin 0.5 kg/ha (89.3%). The effect of *Rhizobium* inoculation was not significant but WCE was more (56.2%) when the seeds are inoculated with *Rhizobium* culture as compared to uninoculated.

3. The loss of nutrients due to weeds in unweeded control was as high as 262.63 N, 60.04 P_2O_5 and 304.61 K_2O kg/ha and minimum in manual weeded treatment. Application of

herbicide with or without *Rhizobium* inoculation appreciably brought down the nutrients removal by weeds.

4. Dry matter accumulation in pea enhanced by different weed management practices. Alachlor at lower dose (0.6 kg/ha) was inferior to control the weeds but at higher dose was recovered in later stage of crop growth. The tallest plant height was recorded under pendimethalin 0.5 kg/ha.

5. Yield attributes *viz.*, number of pods per plant, number of seeds per pod, number of root nodules per plant, dry weight of nodules were enhanced by application of alachlor at 0.6 kg/ha where as *Rhizobium* inoculation treatments did not show any significant effect. Weedy check recorded lowest value of these yield attributes.

6. Manual weeding twice at 15 and 30 DAS recorded higher pod yield of peas followed by pendimethalin 0.75 and 0.50 kg/ha among different weed management treatments. These treatments gave higher pod yield of 169.20, 143.30 and 133.50 per cent, respectively over weedy check. The *Rhizobium* inoculation treatments did not show any significant effect.

7. Hand weeding twice at 15 and 30 DAS recorded highest straw yield (1875 kg/ha) being at par with all the weed management treatments except alachlor at both the doses and increased straw yield 47.83% over weedy check.

8. The weedy check showed the higher weed index (62.85%) as weeded caused greater reduction in yield attributes. Where as, under application of pendimethalin at 0.75 kg/ha it was lowest (9.63%).

9. Overall performance of various treatments brought light on the combined use of *Rhizobium* inoculation and herbicide. In most of all the observations both of the factors, weed management practices and *Rhizobium* inoculation did not show interaction effect, indicates that both of the factors were independent in their effect.

10. Correlation studies indicated that all weed parameters were negatively correlated with pod yield. Whereas, weed parameters showed negative and non-significant correlation with number of seeds per pod.

11. The most advantageous treatment was hand weeding twice at 15, 30 DAS + *Rhizobium* inoculation resulting in higher pod yield of 8720.83 kg/ha with maximum net profit of Rs. 53,856 / ha. The other greater profitable treatments were hand weeding twice without *Rhizobium* inoculation and with *Rhizobium* inoculation which gave net profit of Rs. 50,328 and 50,099 / ha, respectively. The treatment combination R_1W_8 (weedy check + *Rhizobium* inoculation) resulted in a net losses of Rs. 3614 / ha due to profuse growth of weeds reduced yield. The returns per rupee was the highest in manual weeding twice + *Rhizobium* inoculation, pendimethalin 0.5 kg/ha + *Rhizobium* inoculation. The corresponding values for CBR were 2.59, 2.49 and 2.49, for *Rhizobium* inoculation + hand weeding at 15 and 30 DAS, *Rhizobium* inoculation + pendimethalin 0.5 kg/ha and hand weeding at 15 and 30 DAS without *Rhizobium* inoculation respectively.

CONCLUSION

The present one year study indicated that out of three pre emergence herbicides (fluchloralin, pendimethalin and alachlor) tested, with and without *Rhizobium* inoculation, pendimethalin 0.5 kg/ha was at par with hand weeding at 15 and 30 DAS and most effective in controlling weeds (WCE 97.2 to 89.3%) and produced comparable pod yield (8721-8373 kg/ha) of peas with higher cost benefit ratio of 2.59 to 2.49 under middle Gujarat agro-climate zone. The effects of weed management practices and *Rhizobium* inoculation were independent.

FUTURE LINE OF WORK

The following suggestions are made for future line of research work on the basis of present findings:

1. To obtained valid conclusion, the study should be repeated for one more season.
2. Other new herbicides may also be tried for weed management in *Rabi* peas.
3. Weed management and *Rhizobium* inoculation study in *Rabi* peas may also be conducted under different Agro-climatic conditions on different soil types.

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* Original not seen.

APPENDICES

Appendix-I

Analysis of variance for weed parameters, yield attributes, yield and quality

Source of variance	d.f.	Plant population at 20 DAS	Mean sum of square for					
			Plant height (cm)		No. of pods/ plant	No. of seeds/ pod	No. of nodules/ plant	Dry weight of nodules/ plant (mg)
			30 DAS	At harvest				
Replication	3	9522.0	3.842	23.099	0.126	1.151	0.473	0.051
R	1	64.00	3.805	0.203	0.30	0.143	13.662	2.364
W	7	519.143	85.042	46.431	31.998	0.232	1.358	19.271
RW	7	680.714	3.657	1.114	2.722	0.334	0.817	0.492
Error	45	1279.333	3.13	1.896	0.506	0.591	0.947	0.634

contd. …

Weeds count/m^2			Dry weight of weeds at harvest (kg/ha)	Pod yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Total N in soil (kg/ha)	Available P_2O_5 in soil (kg/ha)	Available K_2O in soil (kg/ha)
20 DAS	40 DAS	At harvest							
0.617	1.513	0.503	2020491.12	72596589.031	4153865.679	770.799	1.003	92.247	1366.635
4.121	1.238	3.399	19378.644	353824.98	245438.843	94.262	2.375	44.894	2925.991
175.273	190.257	0.531	21998417.312	26157856.03	853230.99	316.003	5.423	885.68	5919.610
0.667	3.653	0.173	361230.23	2804728.616	82207.062	235.054	0.196	333.051	5598.088
3.559	1.401	0.450	574096.541	1993960.336	133997.884	203.537	0.169	325.089	1490.829

contd. …

Protein (%) of seed				N content (%) of weed	P_2O_5 content (%) of weed	K_2O content (%) of weed
1st	2nd	3rd	4th			
0.659	0.085	0.64	1.494	1.003	0.113	4.355
0.186	0.316	1.227	3.52	2.375	0.060	0.074
1.966	4.781	7.786	5.805	5.423	0.208	6.158
0.713	0.495	0.598	0.577	0.196	0.013	2.132
0.562	0.395	0.445	1.074	0.169	0.047	0.704

Appendix-I

Common cost of cultivation

Sr. No.	Particulars	Cost Rs/ha
1.	Tractor cultivation (4 hrs./ha)	200.00
2.	Planking and opening of furrow (1 PB + 1 labour)	100.00
3.	Layout, fertilizers and fertilizer applications (20 labours)	2100.00
4.	Seed, seed treatment and sowing	14550.00
5.	Plant protection measures (2 labours) Endosel 35 EC (Endosulfan) : 350 Rs./lit. Equalus 25 EC (Quinalphos) : 300 Rs./lit.	460.00
6.	Picking of pods (Four times) (20 labours/picking)	3500.00
7.	Harvesting (10 labours)	400.00
8.	Interest on working capital @ 12% per annum (three months)	640.00
9.	Supervision charges @ 10%	533.00
10.	Land rent @ 16% of gross income	10112.00
11.	Land revenue	50.00
	Total expenditure other than weed control	32645.00